REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Alternative Surface Navy Force Structures for the Future		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER IDA Paper P-1705
7. AUTHOR(s) Jeffrey H. Grotte		8. CONTRACT OR GRANT NUMBER(s) IDA Central Research Program
9. PERFORMING ORGANIZATION NAME AND ADDRESS Institute for Defense Analyses 1801 N. Beauregard Street Alexandria, VA 22311		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE December 1983
		13. NUMBER OF PAGES 89
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

This document is unclassified and suitable for public release.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

U.S. Navy, force structures, cost-effectiveness, maritime nuclear war, contingencies, peacetime presence, cruise missile submarines, cruise missile carriers (aircraft), VSTOL aircraft, aircraft carriers.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Current and projected threats to surface ships in certain high threat areas of the world, e.g., the North Atlantic, suggest that alternatives to the U.S. Navy's carrier-centered. This paper examines the costs and effectiveness of cruise missile equipped submarines and aircraft to replace carriers in high threat areas, and compares a number of aviation support ships for lower threat contingencies.

Copy 36 of 50 copies

IDA PAPER P-1705

ALTERNATIVE SURFACE NAVY FORCE STRUCTURES FOR THE FUTURE

Jeffrey H. Grotte

December 1983

INSTITUTE FOR DEFENSE ANALYSES
PROGRAM ANALYSIS DIVISION

IDA Log No. HQ 82-25057

IDA PAPER P-1705

ALTERNATIVE SURFACE NAVY FORCE STRUCTURES FOR THE FUTURE

Jeffrey H. Grotte

December 1983

INSTITUTE FOR DEFENSE ANALYSES
PROGRAM ANALYSIS DIVISION
1801 N. Beauregard Street, Alexandria, Virginia 22311

IDA Central Research Program

CONTENTS

APPENDICES

FIGURES

TABLES

ACKNOWLEDGMENT

The author wishes to thank Mr. Seymour Deitchman and Dr. Herschel Kanter, both of IDA, and RAdm Charles Tesh, USN (Ret.) for helpful comments and suggestions as this paper was being written. Any errors or other shortcomings, however, are solely the responsibility of the author.

A. INTRODUCTION

The current Administration's ambitious program to rebuild American naval capability has focussed attention on questions of naval force structure. The Navy would like to build a 15 battle group/600 ship force which would be sufficient, Navy spokesmen maintain, to provide a global offense against the Soviet Union and its allies in the event of conflict and, at other times, to fulfill presence and crisis response roles worldwide. By contrast, today's 12 battle group Navy is characterized as being unable to maintain a "margin of superiority"[1] over the Soviets and is "stretched thin"[2] by current overseas deployment.

While most observers concur with the Navy's assertions of increasing Soviet maritime capability and the growing stress on men and equipment from current US deployments, it is not at all evident that these conditions can be rectified by a 25 percent increase in the number of battle groups. Because naval forces must be effective in two increasingly divergent environments, it may be appropriate to re-examine naval force structure and the battle group's central role therein.

The first environment that naval forces must function in is the high threat setting that the Navy foresees in the event

---

[1]Hayward, T.B., "A Report by Admiral Thomas B. Hayward, U.S. Navy Chief of Naval Operations, Before the House Armed Services Committee on the Fiscal Year 1983 Military Posture and Fiscal Year 1983 Budget of the United States Navy," 8 February 1982, p.6.

[2]Ibid.

of a NATO/Warsaw Pact conflict. A new policy of projecting naval forces into Soviet homewaters early in any such conflict has been enunciated by Navy spokesmen[1], and recognized by commentators on naval issues.[2] The purpose of these forays is to destroy as soon as possible the submarines, surface ships, and naval munitions, along with their supporting bases, that pose a threat to military and economic sea lines of communications (SLOCs). This mission, called "offensive sea control," is pivotal to understanding the Navy's view of itself as well as its basis for force structure decisions.

Of utmost concern in this context is the survivability of carrier battle groups. Over the years, the Soviets have accumulated a substantial inventory of antiaircraft carrier forces. Among these are land-based bomber aircraft, such as the Backfire, with long-range antiship cruise missiles, and cruise missile and torpedo submarines in considerable numbers and variety. While the introduction into the fleet next year

---

[1]Statements to this effect by Secretary of the Navy Lehman and ex-CNO Hayward abound. Admiral Harry D. Train II, US Navy Commander-in-Chief Atlantic Command, during testimony before the House Armed Services Committee, February 23, 1981, stated: "In the event of war with the Soviets, I intend to carry the fight to the Soviet homewaters. Strong early action in the forward areas is necessary to defeat the Soviet Navy in the Atlantic area," p.4.

[2]"...perhaps the most dramatic change enunciated by the Reagan Administration is the policy of henceforth the USN will go into the so-called 'high threat' area, such as the Norwegian Sea and Eastern Mediterranean. Actual war plans are, of course, highly classified, but it has been the implicit policy of the USN for at least the last decade that they would stop the Soviet Navy at the so-called GIUK (Greenland-Iceland-United Kingdom) gap. ...Similarly, there was the assumption that, at least for the first few days of any conflict, the Navy would pull out of the Eastern Mediterranean, behind Malta and the toe of Italy. Now, it will be the very explicit policy to go North to the gap and into the Eastern Mediterranean. This new, bold policy might be considered a 'Shangri-la' policy, a strategy of going into the enemy's back yard, something not done by the USN since the rather famous Jimmy Dolittle raid of 1942 against the Japanese homeland...", George, James L., "U.S. Carriers--Bold New Strategy," Navy International, June 1981, p.334.

of the first of the Aegis cruisers will likely improve battle group defenses over today's Terrier and Tartar systems, whether or not Aegis will be equal to the Soviet threat remains to be seen. Certainly, the Soviets have had the 14 or so years of Aegis development to prepare countermeasures.

Although Aegis promises to be an effective system, it will have to be extremely effective to cope with the saturation cruise missile attacks that the Soviets are capable of mounting in their home waters. Moreover, it is not at all evident that Aegis will be able to cope with Soviet nuclear antiship weapons.[1] The use of such weapons against US carrier battle groups, especially battle groups attempting to penetrate within striking range of the Soviet Union, is gaining increased credibility among Western analysts.[2] While the most recent Defense Guidance addresses the problem of maritime nuclear attack, it does so in an equivocal way: "It will be US policy that a nuclear war beginning with Soviet nuclear attacks at sea will not necessarily remain limited to the sea" [emphasis added].[3]

---

[1]In spite of the considerable conventional capabilities of planned and improved SM-2 [missile] systems [such as Aegis], Navy studies have indicated that these missiles may be inadequate to counter high altitude nuclear-armed cruise missiles. Therefore the Navy is pursuing a nuclear-armed version of the SM-2 for use against this threat." (Arms control impact statement for Fleet Air Defense systems, contained in "Fiscal Year 1981 Arms Control Impact Statements, statements submitted to Congress by the President Pursuant to Section 36 of the Arms Control and Disarmament Act," US Government Printing Office, Washington, May 1980, p.382). While nuclear defensive missiles may enhance battle group defenses, they raise two important questions that must be answered: (1) Will they provide the leakproof defense required against nuclear attacks? and (2) How much confidence can the Navy place in an approach that cannot be realistically tested without the resumption of atmospheric nuclear detonations?

[2]See, for example, Douglass, Joseph D. and Amoretta M. Hoeber, "The Role of the U.S. Surface Navy in Nuclear War," Naval Institute Proceedings, January, 1982. The recent discovery that an old Soviet Whiskey-class patrol submarine which ran aground in Swedish waters almost certainly carried nuclear torpedoes should caution those who discount Soviet intentions to employ nuclear weapons.

[3]Wilson, George C., "Pentagon Guidance Document Seeks Tougher Sea Defenses," The Washington Post, May 25, 1982.

It is unclear what an appropriate US response to a nuclear attack on a battle group, which would cause few or no collateral damage concerns, should or would be. Reprisals against the Soviet airbases and ports from which the attack came invite attacks on US bases and ports, or worse--a strategic response. Is it believable that the US would risk that kind of escalation following an attack on a carrier battle group? Reprisals against the Soviet surface fleet would be much less escalatory but, since Soviet surface forces are less central to their wartime requirements than is the case for the US, such mirror-image attacks might be more or less irrelevant to the conduct of the war. Reprisals against Soviet SSBNs may present an intermediate risk of strategic retaliation since these forces are not on Soviet territory, but whether the US will be able to find and prosecute these well-protected assets is uncertain.

Whatever the Soviets' estimate of our willingness and capability to respond, the almost certain efficacy of nuclear attacks on battle groups provides a strong incentive for the Soviets to use nuclear weapons. It should not be at all surprising that Adm. Gorshkov has termed nuclear strikes against targets at sea "practically irresistible".[1]

Hence, the ability of battle groups to survive and operate in high threat areas is questionable and almost certainly depends on Soviet willingness to refrain from nuclear attacks. The mere existence of such an effective threat may limit the usefulness of battle groups through US unwillingness to risk these relatively scarce resources.

The other environment in which naval forces function encompasses peacetime presence, crisis response and limited

---

[1] Gorshkov, S.G., <u>The Sea Power of the State</u>, Naval Institute Press, Annapolis, 1979, p. 202.

conflict--essentially those missions that the US Armed Forces have performed since World War II. Here the concern is not so much vulnerability, since the threats tend to be much smaller, but rather an appropriate mix of forces that combines credible capability with adequate numbers.

Credible capability is mandatory since even in this "low threat" context, possible opponents may have sophisticated antiship weapons which have the potential of coming into play. But it is equally necessary to build sufficient numbers to address simultaneous crises[1] in areas of the world, such as Latin America, where the US heretofore has not focussed much attention. Just how many simultaneous operations to plan for is an open question, however--if a 12 battle group force structure was considered a "one-and-a-half ocean Navy,"[2] it is questionable on the basis of simple arithmetic whether 15 battle groups can satisfy "three ocean requirements."

The thesis of this paper is that these problems are resolvable, but not through the Navy's approach of quantitatively augmenting its current forces without altering its foundation--the general purpose carrier battle group. The belief that a battle group can be designed that can function in all environments has led to a compromise that is unsatisfactory all around. The increasing potential threat that battle groups may face in the event of a US-Soviet conflict has driven up defense requirements resulting in high costs for a given level of

---

[1]"In many periods since World War II we have had to cope with crises, but generally one at a time. What is new--and ominous--in the current situation is the multiplicity of crises, their broad geographic range, and their frequent intractibility to political solution." (A Report by Chief of Naval Operations Admiral Thomas B. Hayward, U.S. Navy, on the Fiscal Year 1981 Military Posture and Fiscal Year 1981 Budget of the United States Navy, 31 January 1980 before the House Armed Services Committee, p.2.)

[2]Statements of this nature were common a few years ago. This quotation, and the one immediately following, taken from the statement of Admiral Hayward cited above.

offensive capability. This, in turn, has resulted in an apparent reluctance on the part of some in the DoD as well as Congress to procure and operate the number of battle groups that the Navy feels is desirable to meet US objectives in peacetime and war. As we have suggested, US battle groups may not be survivable against the more severe Soviet threats, in spite of the heavy defensive investment; on the other hand, for many lower threat scenarios, which many feel are more likely employments of naval power, the defensive assets of a typical carrier battle group may be excessive. Indeed, in the majority of actions in which naval forces have been used in the past, no actual combat took place. This is not to say that defensive assets are unnecessary, only that lower levels may be adequate. Thus, carrier battle groups, because they attempt to span such a wide spectrum of military activities, may represent, simply, an inefficient utilization of resources.

In the future, one can expect an increasing Soviet threat and, probably, more lower order demands on US naval forces, which will only amplify current concerns about the adequacy of a Navy built around the large-carrier battle group. It may therefore be an appropriate time to re-examine some of the requirements for naval forces and to investigate alternative force structures that meet those requirements. Where valid doubts exist about the survivability of the carrier battle group, it may be prudent to procure alternative forces for those contingencies. It then becomes equally appropriate to also re-examine the carrier battle group in the context of its remaining roles and missions to see if costs can be reduced or effectiveness increased.

In this paper, we examine alternative force structures that attempt to satisfy the dual needs of the Navy; that is, ones that provide high threat capability while including a large number of low threat units that can be concentrated or dispersed as

the situation requires. While we adopt the analytical convenience of examining alternative forces as if they are eventual replacements for 15 carrier battle groups, the long lifetimes of ships already procured or authorized dictate a long transitional period between currently existing forces and any proposed alternative. Identification of superior alternatives is necessary, however, in order to direct the transition, i.e., to redirect the procurement of forces to more advantageous systems.

Before proceeding further, we should emphasize that we are addressing only the battle group component of the Navy and not the amphibious, surface action group, or convoy escort portions of the surface fleet. Amphibious shipping is properly determined by the configuration and future of the Marine Corps, an important question which goes beyond the scope of this paper. The surface action groups, of which the Navy only foresees four, are a relatively minor portion of the fleets. Built around refurbished battleships, these groups have uncertain roles. Experience with them over the next decade or so should provide evidence of their utility and whether the concept should be expanded or deleted. The convoy escort component is also relatively small (both in terms of numbers of ships and costs) and consists primarily of frigates. Even major changes in the surface action group or convoy escort portion of the fleet would have a small effect on overall Navy budgets. Therefore we believe that it is correct to concentrate on the battle groups, which consume the greatest amount of resources and also receive the greatest attention, both within the Navy and without.

Finally we note that the alternatives investigated here are, of course, not the only ones feasible. Other approaches can and should be explored. We believe, however, that the more attractive of these approaches will share with ours a

move away from the all-purpose battle group to a mix of systems to match different levels of conflict intensity.

1. Life Cycle Costs of the 15 Battle Group Navy

It is almost a tenet of military analysis that forces be compared on the basis of both effectiveness and costs. While "cost effectiveness" is sometimes analyzed and occasionally misused, it nevertheless is helpful to compare the effectiveness of force structures that have equal cost, and we will establish that cost on the basis of the Navy's 15 battle group goal.

For planning purposes, the Navy has determined a "Surface Combatant Force Level Objective"[1] that comprises, for every two carriers, three CG-47 Aegis ships, five of the proposed DDG-51 and/or CGN ships and four DD-963 ASW escorts. For high threat areas, no fewer than two carriers would be used together in order to ensure full time mutual support. Thus the notional two-carrier battle group will consist of the ships shown in Table 1.

Table 1. NOTIONAL TWO-CARRIER BATTLE GROUP

2	CV/CVN
3	CG-47
5	DDG-51/CGN
4	DD-963

Our comparisons of the capability of this battle group with the alternative forces will be on the basis of 30-year

[1]Department of Defense Authorization for Appropriations for Fiscal Year 1982. Hearings Before the Committee on Armed Services, United States Senate, Part 4, Sea Power and Force Projection, March 1981, p.1900.

life cycle costs. Life cycle costs are an estimate of the total costs that are expected to be incurred over the operational life of a system. For this paper, life cycle costs are the total of acquisition costs and operation and support costs for thirty years of operations.[1] The 30-year time period is chosen since it is the approximate lifetime of ships and twice the approximate lifetime of sea-based aircraft.

Life cycle costs are rather infrequently discussed in the open literature; public debate generally focusses on procurement costs. We nevertheless feel that life cycle costs are more appropriate since they take note of a number of salient differences between systems. In addition to differences in lifetimes, for example, life cycle costs consider the relatively high ratio of aircraft operating and support costs to procurement costs compared with those of ships.

The 30-year life cycle cost of the Navy's Surface Combatant Force Level Objective (SCFLO) battle group elements are summarized in Table 2. To the combatants we add a portion of the costs of underway replenishment (UNREP) ships, which are required to support the battle group with fuel and supplies either in combat or during peacetime forward deployments. The assumptions upon which Table 2 is based may be found in Appendix A.

[1] To be strictly correct, life cycle costs also include unsunk research and development (R&D) costs. The correct allocation of these costs among different systems is not a clearcut matter, however, and we will not include R&D costs in our costing procedures.

Table 2. 30-YEAR LIFE CYCLE COSTS OF 15 BATTLE GROUP FORCE STRUCTURE (Billions of FY-1982 Dollars)

Element	Cost
15 Carriers and Air Wings	464
23 CG-47	61
6 CGN	20
31 DDG-51	55
30 DD-963	48
UNREP Ships	108
Total	756

B. FORCES FOR OPERATION IN HIGH THREAT AREAS

In 1978, the proceedings of a conference sponsored by the American Enterprise Institute for Public Policy Research were published in a volume entitled Problems of Sea Power As We Approach the Twenty-First Century.[1] In a paper entitled "Protecting the Fleet," David Kassing, the President of the Center for Naval Analyses, identified a number of technological developments that bear on the survivability of carrier battle groups should they ever come under attack. Among these developments were:

- ocean surveillance systems,
- antiship missiles, and
- nuclear weapons.

Considering the impact of all three of the developments, one begins to question the ability of carrier battle groups to survive long enough to be effective in areas close to the

[1]George, James L., ed., Problems of Sea Power As We Approach the Twenty-First Century, American Enterprise Institute for Public Policy Research, Washington, D.C., 1978.

Soviet Union. Since carrier operations in waters near the Soviet Union appear to be the keystone of the Navy's current posture, any indication that carriers will be unable to carry out high threat missions demands re-examination of the called-for additional carrier battle groups.

1. Carrier Battle Group Vulnerability

The Soviets have created an impressive structure for anti-carrier warfare. It comprises the Soviet Ocean Surveillance System (SOSS) for detecting and targeting US surface combatants, and a variety of long-range aircraft, submarines and surface ships all armed with antiship cruise missiles.

The SOSS is a coordinated amalgam of radar and electronic intelligence satellites, reconnaissance aircraft, land-based over-the-horizon radars, radio direction-finding networks, acoustic systems and Soviet submarines and surface ships of all kinds, both military and nonmilitary.[1] There is little doubt that this system provides coverage that could deny US naval forces the advantage which mobility in vast ocean areas used to provide: location uncertainty. Moreover, detection is increasingly becoming synonymous with targeting, especially as the Soviets develop satellite systems which not only can provide data sufficiently accurate for targeting but also can be communicated "directly to Soviet missile-launching ships or aircraft."[2] While counters exist to the SOSS, its coordinated nature suggests that degradations to one component can be compensated for, at least partially, by other components. To counter the SOSS effectively, then, requires concerted efforts against all of its elements. However, success depends on being

---

[1] Jane's Defense Review, Vol. 2, #3, 1981, p.189.

[2] Lacouture, John E., "Is the Navy's Technology a Shaky Crutch?," Defense Electronics, February 1981, p.88.

able to identify vulnerable aspects of the SOSS, which the US has apparently neglected. In discussing not only the SOSS but in fact the entire Soviet command and control system, Adm. Worth Bagley (former Vice Chief of Naval Operations) writes: "On the Western side...there is a lack of expertise in identifying weaknesses in the Soviet system."[1]

Thus, Soviet ability to detect, locate and target US carrier battle groups approaching "Soviet homewaters" is becoming less doubtful. What remains in doubt is the ability of carrier battle groups to survive an attack by Soviet medium- and long-range bomber aircraft and submarines, both armed with antiship cruise missiles. The Navy frequently addresses this question by pointing out that carriers are perhaps the Navy's least vulnerable ships to conventional cruise missiles and that they are protected by the layered defense of the battle group. This layered defense, composed of the outer air defense (F-14s), and area air defense (Tartar and Terrier systems, with Aegis in the offing), and the point defense systems (CIWS, NATO Sea Sparrow, etc.) is supposed to effectively attrit the number of incoming ASCMs to a point that only a negligible number arrive at the carriers. Much debate has centered on whether this actually can be achieved.

A number of knowledgeable writers have called into question the capability of battle groups to defend themselves. William D. O'Neil, III, Director of Naval Warfare in the Office of the Undersecretary of Defense Research and Engineering, writes that there are "fundamental asymmetries" between attacking aircraft and submarines and defending battle groups and that "simple logical analysis shows that many of these inherently favor the

---

[1]Bagley, Adm. Worth H. (Ret.), "Sea Power, Neglected Key to a Revitalized NATO Strategy," International Defense Review, 4, 1978, p.9.

attack under present conditions."[1] Among the factors cited by O'Neil are:

- The mobility of the attacker and his ability to determine the time and location of the attack.
- The option of the attacker to allocate a substantial fraction of his forces against individual targets sequentially.
- The greater difficulty we face in tracking the enemy's aircraft and submarines as opposed to the relative ease through which surface ships can be detected and tracked.

Although Mr. O'Neil does not conclude that these obstacles cannot be overcome, evidence that the Navy is concerned with these problems can be gleaned from an article by Adm. Stansfield Turner (Ret.) in the New York Times Magazine in May 1981:

> ...we are reluctant to risk [carriers] in combat. This was dramatically demonstrated during last year's hostage-rescue effort. When air support was needed well inside the Persian Gulf, the Navy insisted on keeping its carriers outside--though the potential opposition was only the enfeebled Iranian Air Force and Navy.[2]

To be sure, the advent of the Aegis cruiser in 1983 (after some 14 years of development) should contribute significantly to the defense of the battle group against conventional anti-ship cruise missiles, but until this system is in the fleet and realistic exercises are conducted, the only knowledge of the contribution Aegis can make belongs to those who perform detailed computer simulations, and from the two Aegis test-beds, the Norton Sound and the land-testing facility.

However, there is one threat to the carrier battle group that is probably too severe for even Aegis to handle--the Soviet

---

[1] O'Neil, William D. III, "Naval Anti-Air Warfare," National Defense, Vol. LXV, No. 365, February 1981, p.55.

[2] Turner, Stansfield, "Toward a New Defense Strategy," the New York Times Magazine, May 10, 1981, p.17.

maritime tactical nuclear threat. Because of the immense damage which could be inflicted by a single nuclear warhead on a bomber- or submarine-launched cruise missile,[1] battle group defenses would have to be essentially 100 percent impenetrable to protect the battle group against this sort of attack. It is obvious from the Navy's repeated assertions that large carriers can absorb numbers of conventional cruise missile hits that not even they believe battle group defenses are that effective.

The Navy has generally downplayed the nuclear threat. Recently, Vice Adm. M. Staser Holcomb, then Director of Navy Program Planning, testified before a congressional subcommittee:

> The Soviets write about, talk about, exercise, and, we think, carry tactical nuclear weapons when they put their combatants to sea. They are doing it to a degree that we have long ago stopped doing in this country. They write of a combined arms doctrine on land or at sea, which means the interchangeable use of conventional, nuclear, and chemical weapons. ...We simply do not deal in those terms.
>
> Our latest entries in the field of tactical nuclear war at sea are weapons with 20-year-old technology, in declining numbers. This creates an imbalance in the way the two navies must look at their roles and the possible nature of warfare. ...

---

[1] Another threat that is too little discussed is that from Soviet ballistic missiles which would almost certainly employ nuclear warheads to compensate for targeting inaccuracies. On a 1981 West German television broadcase, a Soviet spokesman, when asked at what Soviet medium range missiles were aimed, remarked that they were "aimed at American forward-based nuclear systems--that is, at the American arms systems stationed on American <u>aircraft carriers</u> and submarines cruising around Europe..." (Emphasis added. From Gouré, L. and M.J. Deane, "The Soviet Strategic View," <u>Strategic Review</u>, Summer 1981, pp.79-80.) The Soviets are also known to have investigated a submarine-launched ballistic antiship missile, the SS-N-13 (Polis, D., "New Missile Threatens U.S. Fleet," <u>San Diego Union</u>, October 6, 1975, p.A-1.) The degree to which the Soviets have solved the complex targeting problems inherent in using land- or sea-based ballistic missiles against surface ships is open to speculation, but the lack of attention this threat appears to have received from US planners suggests that the Navy is unprepared to counter it.

> There is an imbalance today. The Soviets clearly have the momentum going in the area; and we do not...[1]

While Adm. Holcomb notes that the Navy is "working very hard to assess and revitalize our capacity for countering Soviet capabilities and tactical nuclear warfare at sea," there is, as Adm. Holcomb admits, a long history of unsuccessful grapplings with this problem in spite of the fact that it was recognized very early. As early as 1957 Dr. Edward Teller noted what some consider obvious:

> Looking at [an aircraft carrier]...it looked to me like quite a good target. In fact, if I project my mind into a time when not only we, but also a potential enemy, have plenty of atomic bombs, I would not put so many dollars and so many people into so good a target.[2]

While it is true that the US in general has failed to form a cohesive doctrine in which the capabilities of nuclear weapons as well as their "deterrent value" are adequately considered, the Navy has been particularly consistent in avoiding the possibility that Soviet nuclear weapons might require a new look at naval force structure. Not only do major naval force structure studies such as Sea Plan 2000 ignore the possibility of US-Soviet nuclear conflict[3] but also "the senior course at the US Naval War College--an institute whose stated mission is to 'enhance the professional capabilities' of future military leaders and to develop 'advanced strategic and tactical concepts for the future employment of naval forces'--contains essentially notion on any aspect of tactical nuclear weapons employment."[4]

---

[1]Hearings before a subcommittee of the Committee on Appropriations, House of Representatives, Ninety-Seventh Congress, First Session, Navy/Marine Corps Procurement Overview, Thursday, May 21, 1981, pp.646-647.

[2]Teller, Edward, "The Nature of Nuclear Warfare," Air Force Magazine, January 1957 as quoted in George, James L., op.cit., p.212.

[3]Brooks, Capt. Linton F., US Navy, "Tactical Nuclear Warfare: The Forgotten Fact of Naval Warfare," US Naval Institute Proceedings, January 1980, p.29.

[4]Ibid.

Three months after Adm. Holcomb testified on the need for a reassessment of the Navy's view of maritime nuclear warfare, Secretary of the Navy Lehman, speaking on a Washington area radio talk show, made the following statement after pointing out that "a carrier is far better able to withstand a nuclear engagement than a smaller ship,":

> ...war at sea does not take place only at sea. You have to attack the naval bases and the sources of support and supply and ammunition of the--the naval forces.
> So, if you go nuclear afloat, you're going to be nuclear <u>ipso facto</u> ashore at the naval facilities.[1]

The first argument echoes the Navy's position that carriers are less vulnerable to conventional weapons than other ships. This may well be true but effectively misses the point. A carrier may indeed be able to withstand nuclear weapons effects better than other ships, but the overpressure and high winds generated by a nuclear burst can cause general and severe damage to the carrier's vulnerable air wing long before major damage is sustained by the ship itself. Without an operable air wing, a carrier, being otherwise essentially without offensive armament, is of little value.

The second argument is also somewhat misleading. An attack at sea is an attack at sea; it is not, "<u>ipso facto</u>," an attack on shore-based facilities. Should the carriers be neutralized in this manner, no amount of logistical back-up will make up for that loss of capability. Also, as we noted in the Introduction, many feel that there is surely a distinction between a nuclear attack at sea against US forces approaching Soviet homewaters and hence in an offensive posture and a nuclear attack on US naval facilities and their collocated civilian populations. While US strategists should rightly have a range of options to respond to any attack on US forces,

---

[1]Braden-Buchanan Show, WRC Radio, August 24, 1981, Radio TV Reports, Inc., Chevy Chase, MD, p.14.

pretending that a carrier and a naval base are equivalent in terms of appropriate US response, as Secretary Lehman seems to be doing, is an oversimplification.

It is worthy of note, however, that a NATO nuclear response to a Soviet nuclear maritime attack may, because of the obvious asymmetries in naval force structure, be highly escalatory. Because a Soviet nuclear attack will likely come from land-based aircraft and submarines, a response against Soviet surface combatants is not the most direct possible. More appropriate would be retaliation against Soviet naval and air bases, but this also could evoke a nuclear attack on US ports or even a strategic response. The use of nuclear ASW weapons against Soviet submarines also could be an appropriate response but could be equally risky if done in Soviet homewaters and the Soviets felt their submarine-based strategic weapons threatened in this manner. Moreover, this would have no effect on Soviet naval aviation. In this respect, there appears to be an imbalance between the dangers faced by the Soviet Union in attacking carriers with tactical nuclear weapons and possibly greater dangers facing NATO in responding to that attack.[1]

This is not to argue that we will inevitably engage in maritime nuclear war or that the Soviets would resort to nuclear weapons against carriers,[2] however, if we are building a Navy whose fundamental role in a US-Soviet conflict is offensive sea control which requires operations near the

---

[1]We should note that the Navy is currently interested in nuclear warheads for its Standard missiles. Battle group defenses relying on nuclear warheads raise questions of nuclear release, nuclear loadout (will carrying enough nuclear weapons to counter possible nuclear attacks mean the reduction of conventional weapon capacity?), and whether own-system degradation from nuclear phenomena can be avoided.

[2]The almost certain evidence that an aged Soviet Whiskey-class submarine that ran aground off of Sweden in October 1981 while patrolling Baltic waters carried nuclear weapons strongly suggests that the Soviets are prepared to use nuclear weapons at sea.

Soviet mainland, then to invest in battle groups--when an obvious and apparently effective counter to them exists--is to risk vast amounts of money on systems with uncertain wartime potential. Moreover, insofar as that uncertainty exists, investment in battle groups, as opposed to other perhaps more effective forces, may actually result in degraded Western security.

2. Ensuring Future Naval Capability in the High Threat Environment

There are three responses that the US can make to the Soviet anti-carrier threat. The first is to ignore it and to operate the battle groups in the manner the Navy appears to want to do. Such boldness could pay off but could also result in devastating losses. The second is to relinquish high threat naval operations and to operate carrier battle groups only under less threatening circumstances. The major weakness of this approach is that we cannot be certain of the requirements of a future conflict. Therefore, giving up, a priori, maritime capability in high threat areas imposes a limitation on US strategic and tactical planning that we may not wish to live with. Also, Soviet cruise missile submarines and expectations of future longer range Soviet bomber designs for maritime use will extend what might be considered "high threat areas" well beyond "Soviet homewaters." Indeed, even today, Backfire bomber coverage extends well south of the Greenland-Iceland-United Kingdom (GIUK) gap.

A more positive course of action that the US can take is to develop a broader based naval force structure that, instead of concentrating offensive capability in few and vulnerable carrier battle groups, includes systems for high threat areas that offer usable offensive capabilities and are less vulnerable to tactical nuclear weapons than are surface ships.

What sorts of systems might these be? If we ignore strategic ballistic missiles (whose use, it seems to us, would

surely initiate strategic nuclear war) and surface vessels (because of their vulnerability), then about the only means of penetrating the high threat areas surrounding the Soviet Union is with submarines and cruise missile-carrying land-based aircraft.

3. Submarines

The advent of the submarine-launched cruise missile provides the submarine land-attack capabilities as well as enhancing anti-surface ship effectiveness. While less flexible than sea-based aircraft in that mobile targets ashore cannot be attacked and damage assessment would have to be performed by external systems, the cruise missile's potential accuracy and ability to penetrate enemy air defenses suggest that submarines, given sufficient numbers of cruise missiles, will be effective against a variety of important Soviet targets: airfields, petroleum tank farms, railroad structures, command, control and communication nodes, and so forth.

Submarines are not invulnerable, but their vulnerability is of a different sort than that of surface ships. An obvious example is that submarines are not subject to attack by massed bomber raids as are surface ships. Nor, obviously, can they be attacked by anti-surface cruise missiles. Rather, intricate ASW procedures are necessary to detect, then localize, then attack and reattack if necessary. While nuclear weapons can be used against submarines, they affect chiefly the attack portion of this prosecution sequence. Detection and localization still must be performed since nuclear weapons effects attenuate relatively quickly under water. Moreover, because the attacking aircraft ship or submarine may have to take evasive actions if using nuclear weapons, and because underwater nuclear detonations interfere with sonar operations for a period of time, the possibilities for immediate attack assessment and reattack will

be curtailed. Thus, the advantage of nuclear weapons over conventional weapons against submarines is considerably less than against a carrier; submarines therefore appear to offer relatively good survivability characteristics for operations in high threat areas. The only question is whether enough submarine-based firepower can be brought to bear on Soviet targets in comparison with the carrier-based firepower. This depends on how many cruise missiles are carried by an individual submarine, and on submarine costs.

A recent article in Aviation Week and Space Technology[1] suggests that, at a minimum, a Los Angeles-class attack submarine will be able to carry 23 Tomahawk cruise missiles--15 in the new submarine vertical launch system and, in addition, eight internally to be launched through the torpedo tubes. Because the internal weapon load of the submarine is known to be considerably greater than eight, we will assume a cruise missile capacity of 25.[2] The procurement cost of one such submarine is about $673 million in FY 1982 dollars.[3]

Of course, a specially designed submarine might be better for this purpose than a modified SSN-688. The Navy has shown little interest in this type of submarine, however. We can nevertheless estimate the cost of at least one design of cruise missile submarine by examining the recent Navy proposal to convert retiring Polaris submarines into cruise missile carriers. Such a conversion would permit each submarine to carry up to

---

[1]"Service Sets Top Priority on 150 Offensive Ships," Aviation Week and Space Technology, August 31, 1981, p.59.

[2]Other sources give the vertical launch system capacity as 12 missiles. This would require only 13 missiles carried internally to achieve a total of 25, which is within the SSN-688's capacity.

[3]Mitchell, Douglas D., Shipbuilding Costs for General Purposes Forces in a 600-Ship Navy, Congressional Research Service Report No. 82-23F, February 16, 1982, p.CRS-24. This report specifies a procurement cost of $633 million. We add $40 million to cover the incorporation on the vertical launch system in the forward ballast tank.

125 cruise missiles[1] at a conversion cost of about $16.5 million in FY82 dollars per ship. The cost of a new Polaris boat, updated to FY82 dollars, is between $600-$700 million.[2] Obviously, such a submarine is a more cost-effective cruise missile carrier than the Los Angeles-class upgrade, although it may be inferior in other respects.

4. Land-Based Aircraft

Long-range, land-based aircraft provide another opportunity to augment naval forces with systems that are less vulnerable to tactical nuclear weapons. Increased survivability comes not directly from system characteristics, as with submarines, but from the fact that these aircraft can be based in rear areas near population centers, such as the United Kingdom or even in the United States, and still be within range of major Soviet maritime targets. While aircraft and airbases are certainly vulnerable to nuclear weapons attack, their potential locations can be arguably said to have a deterring effect. That is, nuclear attacks on these airbases introduce escalation considerations into Soviet decision-making that are possibly much more constraining than those surrounding an attack on a carrier battle group far out at sea.

Land-based aircraft can perform a number of naval missions, including most of those performed by sea-based aircraft. Power projection and anti-surface missions can be accomplished by bomber-type aircraft with cruise missiles or other stand-off ordnance or, for low threat operations, gravity weapons. Mining also can be performed. A more novel use for this type of aircraft would entail equipping it with air-to-air missiles for

---

[1] Defense Daily, March 14, 1980, p.74.

[2] Sapolsky, Harvey M., The Polaris System Development, Harvard University Press, Cambridge, Massachusetts, 1972, p.142. The unit cost of a Polaris submarine in the "early 1960s" is given as $110 million.

use against Soviet naval bomber aircraft targeted against US shipping. Such employment is not completely farfetched. A few years ago, the Pentagon did indeed consider an interceptor version of the B-1 for precisely that purpose.[1] Nor is the use of land-based aircraft for naval missions a fundamentally new idea. Land-based maritime P-3s have been employed fruitfully for almost two decades for anti-submarine patrols (and more recently, with the addition of Harpoon, for anti-surface operations), replacing the land-based P-2s before them. B-52s have long had collateral maritime missions, such as mining, and even the aforementioned task of intercepting Soviet bombers by land-based interceptors has been acknowledged by the Air Force,[2] although the use of Air Force aircraft for fundamentally naval missions may lead to conflicting priorities. Land-based aircraft owned by the Navy for such purposes would eliminate such interservice friction, but even this would not be a totally original concept--the Navy operated bombers for sea control during World War II.[3]

One candidate for a naval land-based aircraft is the B-1B currently being procured by the Air Force primarily for strategic purposes but for which, it is acknowledged, maritime support missions exist. Among those, according to an Aviation Week and Space Technology article are: "worldwide power projection,... amphibious force support,...fleet air defense, protection of the sea lines of communications, and mining."[4]

---

[1]"Ocean Sciences News," 1978, p.5.

[2]Department of Defense Authorization for Appropriations for Fiscal Year 1979. Hearings Before the Committee on Armed Services, United States Senate, Part 2--Authorization, February-March 1978, p.1426.

[3]Sullivan, Capt. William K., U.S. Navy, "Now is the Time to: Rethink, Redesign, and Redeploy Naval Aviation," Naval War College Review, March/April 1982, p.14.

[4]"USAF Recommends New Combat Aircraft," Aviation Week and Space Technology, May 11, 1981, p.20.

Unless the design is modified somewhat, the B-1B can carry up to 22 cruise missiles (the modifications enable another eight cruise missiles to be added). No details of an interceptor version of the B-1 have been released, to our knowledge. There would seem to be no reason, however, to assume that the B-1B could not be equipped to carry Phoenix missiles in at least as many numbers as cruise missiles. The range of the B-1B is about 5,000 nmi without refueling.[1] Estimates of the procurement cost of the B-1B vary between $200 million and $400 million per aircraft.

Proposals have been made in the past to deploy cruise missiles on wide-body or cargo-type jet aircraft. Such a cruise missile carrier (CMC) might carry 60 or more cruise missiles at a procurement cost of about $100 million per aircraft.[2]

5. Cost and Effectiveness

In this section we will compare the cost and effectiveness of these options to traditional sea-based forces.

As we noted in the Introduction, the Navy bases its planning on a notional Surface Combatant Force Level Objective (SCFLO). While it is true that the composition of an actual battle group is determined by the circumstances of its mission, we also will employ the convenience of a notional battle group. For high threat areas, no fewer than two carriers would be used together in order to ensure full-time mutual support, so we compare the alternatives to a two-carrier battle

---

[1]Taylor, John W.R., ed., Jane's All the World's Aircraft 1977-1978, Franklin Watts, Inc., New York 1977, p.391.

[2]This cost, updated to FY82 dollars, was ascribed in a memo by the then Defense Secretary Harold Brown in "New U.S. Plane for Cruise Missile," The Tribune, New York, 30 March 1978, p.14.

group as specified by the SCFLO. The 30-year life cycle cost of such idealized battle group is 2/15 of the $756 billion for a 15 battle group Navy or $100.8 billion (in FY 1982 dollars). This is compared to the life cycle costs of the alternative systems in Table 3. Refer to Appendix A for the assumptions on which these totals rest.

Table 3. 30-YEAR LIFE CYCLE COSTS OF ALTERNATIVE SYSTEMS

Alternative	Cost
Two-Carrier Battle Group	100.8 billion
CMC	562 million
B-1B	1,562 million
SSN-688 (VLS)	1,346 million
SSGN	1,300 million

a. Effectiveness Comparisons

Comparing the "effectiveness" of the alternative force options with a carrier battle group is not entirely straightforward since one is comparing manned, sea-based aircraft delivering short-range ordnance with cruise missiles.[1] Whereas penetrating manned aircraft possess characteristics of flexibility and adaptability, cruise missiles must be preprogrammed and can only attack those targets for which guidance data have been obtained. Current US plans to deploy both nuclear and conventional cruise missiles suggest that adequate targeting data can be obtained.

[1] The B-1B (but not the CMC) can deliver much the same type of ordnance as sea-based aircraft provided that it penetrates the enemy's defenses. We will not examine this particular capability, however, but instead focus on the B-1B as a cruise missile carrier.

We will compare only the ability of all the alternatives to deliver ordnance over time, implicitly assuming that equal amounts of ordnance, whether delivered by sea-based aircraft or by cruise missiles, are equally effective.[1] The period of time over which ordnance is delivered will vary parametrically. Since the purpose of operating in Soviet homewaters is to quickly dispose of Soviet forces before they can become a threat to the SLOCs, the time over which these operations are crucial is on the order of days or, at most, weeks rather than months. Therefore, we will establish thirty days as the upper limit of our investigations, realizing full well that even this may be excessively long for "offensive sea control" operations.

A typical light attack aircraft, such as an A-7, can deliver three to four times the payload of a cruise missile at ranges of 500 nmi or more.[2] We assume that this value also is appropriate for the F/A-18 which is to replace the A-7 in future carrier air wings. If we further assume that a sea-based attack aircraft can average 1-2 sorties per day for extended periods and that medium attack (A-6) aircraft can carry 1-2 times the payload of a light attack aircraft, then a two-carrier battle group with its 20 medium attack and 48 light attack aircraft can deliver between 204 and 704 cruise missile "equivalents" per day.[3] We will base our comparisons, then, on an

---

[1]Note that we are implicitly restricting the comparison to a target set comprising the sorts of known, fixed targets against which cruise missiles are effective. Mobile targets (other than ships) and targets of opportunity are not subject to cruise missile attack given their present concept of use. We do not believe that this is a serious shortcoming in the analysis as long as we restrict our discussion to Soviet targets in areas such as the Kola Peninsula where fixed military installations abound.

[2]Burt, Richard, "Local Conflicts in the Third World," Chapter 7 of Cruise Missiles: Technology, Strategy, Politics, Richard K. Betts, ed., The Brookings Institute, Washington, D.C., 1981, p.214.

[3]For these discussions, we will ignore reliability and availability considerations.

intermediate value: the two air wings will be presumed to deliver 500 cruise missile equivalents per day (over extended periods) at a sortie rate of 1.50 sorties per aircraft per day. This is consistent with an assumption that each light attack sortie delivers 3.8 cruise missile equivalents per sortie and each medium attack aircraft delivers 7.6 cruise missile equivalents per sortie.

For our alternative force options, we will assume that both the CMC and the B-1B can achieve an average sortie rate of 0.50 sortie per aircraft per day. A much greater time is necessary for submarines to transit to their area of operations, launch their cruise missiles, return to base and rearm for another mission. We assume that 15 days is adequate for this cycle. If five days total is required for the missile launch and refit portions of the cycle, then one-way transit distances on the order of 2400 nmi can be accommodated if the submarines travel at an average 20 knots.

Figure 1 compares the cumulative cruise missile delivery capabilities of the alternative equal cost forces. The numbers of submarines and aircraft equal in life cycle cost to the two carrier battle group are shown in Table 4. For sea-based aircraft, cruise missile equivalents (as discussed above) are shown. The comparisons are between equal life cycle cost forces in which ordnance costs are not included. Up to thirty days of cruise missile (or equivalent) delivery capability is shown. The step functions representing the two submarine designs presuppose that all submarines operate in synchrony, launching their missiles on day 1 and returning on day 16. Other distributions of submarine activities over time are, of course, possible.

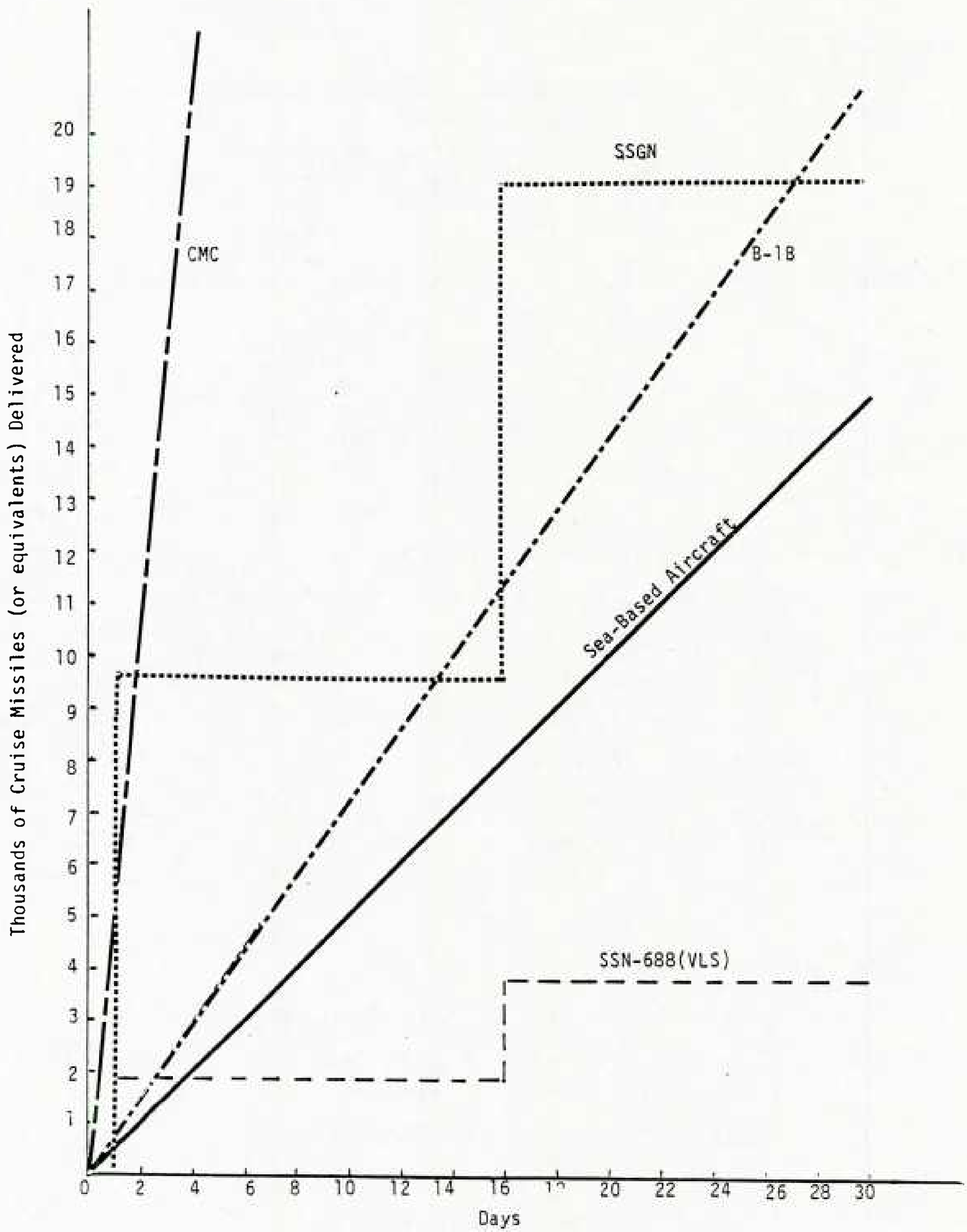

Figure 1. CRUISE MISSILE DELIVERY POTENTIAL OF EQUAL LCC FORCES

Table 4. EQUAL LIFE CYCLE COST FORCES TO A TWO-CARRIER BATTLE GROUP (ordnance costs not included)

Systems	Numbers
CMC	179
B-1B	65
SSN-688 (VLS)	76
SSGN	78

Under our assumptions Figure 1 indicates that three of the alternatives, the two land-based aircraft and the SSGN, have tremendous potential for delivering ordnance compared to a two-carrier battle group on an equal life cycle cost basis. Even the SSN-688(VLS), a generally less cost effective system over the long run, dominates the cumulative capability of the battle group for the first few (and perhaps most crucial) days. However, these comparisons are somewhat misleading since they ignore two important factors that can affect the relative desirability of the alternative means of delivering ordnance. The first factor is ordnance costs, which can be significantly higher for those systems employing the relatively expensive cruise missiles; the second is the differing vulnerabilities of the alternatives under combat conditions.

b. Ordnance Costs

It is frequent practice to ignore most ordnance costs in military cost-effectiveness analyses. One justification frequently given is that ordnance costs are really wartime costs since those expended, except for initial loads, will be the product of wartime production. Since the NATO/Warsaw Pact conflict for which this planning is intended is usually accorded only a low probability of occurrence, ordnance costs therefore should be heavily discounted or ignored. By comparison, the wartime production rates of complicated items

such as cruise missiles probably will not be much higher than peacetime rates and so stockpiles will have to be established, particularly for the early-into-the-war tasks envisioned in this chapter. Since stockpile costs are peacetime costs, we believe that the cost effectiveness comparisons will be more accurate if cruise missile costs are included.

The procurement cost of a cruise missile is about $2.6 million,[1] with a 30-year life cycle cost of about $13 million. For comparison, the procurement cost of an equivalent quantity of carrier aircraft-delivered ordnance (1000 lbs) can cost less than $2000 to procure, with a life cycle cost assumed to be $3000.[2]

These figures tend to overstate the differences between cruise missile and carrier aircraft ordnance costs because our carrier aircraft ordnance costs are based entirely on gravity-bomb-type weapons. Carrier aircraft more likely would deliver a mix of weapons, which would no doubt include more expensive (but still less costly than cruise missiles) HARMs, Mavericks, and/or other air-to-surface munitions. Should the Navy shift to a more complex stand-off weapon in the future, such as the Medium Range Air-to-Surface Missile (MRASM), which is itself a cruise missile, the cost gap between carrier aircraft-delivered ordnance and cruise missiles will be much smaller, if not eliminated. We will nevertheless retain the assumption of negligible carrier aircraft ordnance costs, but the reader

---

[1]Department of Defense Authorization for Appropriations for Fiscal Year 1982, Hearings Before the Committee on Armed Services, United States Senate, 97th Congress, First Session, Part 4, Sea Power and Force Projection, March 1981, p.2138. Life cycle costs are assumed to be five times procurement costs (see Appendix A).

[2]Military Cost Handbook, Data Search Associates, 1981, p.9-3. This reference puts the cost of a MK-84 2000-lb bomb at about $3000. The cruise missile carries only a 1000-lb warhead, so we place cruise missile "equivalent" procurement cost at $1500. We assume that life cycle cost is only twice procurement cost for unsophisticated ordnance.

should be aware that more realistic costs for these munitions would tend to favor the alternative systems.

c. Attrition

We have discussed the vulnerability of surface ships in high threat areas. There is substantial reason to believe that surface forces are not capable of enduring in the face of the sorts of threats expected to be encountered in these areas. If true, the ordnance delivery capability of battle groups in this environment would be significant. There is far from unanimous agreement on this point, however, and in the following calculations we will ignore attrition to surface ships and compare the alternative system to carrier aircraft under the assumption that the carriers can remain effective throughout the time frames investigated.

Carrier aircraft, on the other hand, will necessarily face Soviet air defenses if they are to launch the short-range inexpensive ordnance we have ascribed to them. These defenses can be expected to exact a certain amount of attrition, which will, of course, depend on the actual circumstances of the scenario. Rather than specify those circumstances, we will examine carrier aircraft parametrically, with four different values of aircraft attrition alternatively assumed: one percent, five percent, ten percent, and twenty percent attrition per sortie. While it is not possible to foretell what attrition rates to expect, historical evidence suggests that those rates may be considerable. Table 5 presents selected loss rates per sortie for certain World War II Pacific theater operations. In the European theater also, attacks on certain key targets well exceeded 20 percent,[1] although the overall

---

[1]Examples include allied attacks on Ploesti (1943), Schweinfurt (1943), Regensburg (1943), and German attacks on Malta (1941) and the Remagen Bridge (1945).

Table 5. SELECTED ATTRITION RATES

Date	Campaign	US Loss Rate (percent) on Attack Missions
8 May 42	Coral Sea	16
4 June 42	Midway	36
1 Apr 43	Solomon's Fighter Sweep	15
5 Nov 43	Rabaul Strikes	10
19 June 44	Phillippine Sea	9
3-9 Jan 45	Formosa Strikes	3
16 Feb 45	Japan Strikes	12

Source: Timenes, Nicolai, Jr., Defense Against Kamikaze Attacks in World War II and Its Relevance to Anti-Ship Missile Defense, Center for Naval Analyses, OEG Study 741, November 1970, *passim*.

attrition rate in World War II was only a few percent. Both aircraft and air defenses have improved since then, of course, and high aircraft attrition rates remain certainly possible, particularly in areas vital to Soviet naval operations.

For reasons similar to those given above for surface ships, we will not include damage to airbases supporting land-based aircraft. If one believes that the Soviets will attack such bases with sufficient force to shut them down, then those aircraft are not a credible means of attacking targets in high threat areas. If, however, one believes that the rearward locations of these bases, in addition to what defenses may be present, provide adequate protection, then questions of aircraft survival in flight and cruise missile attrition must be addressed. The long range of the cruise missiles should minimize attrition to the long-range land-based aircraft once they are in flight as long as we limit their targets to coastal areas--the same areas that carrier aircraft would presumably

cover.[1] We therefore assume no attrition to the land-based aircraft themselves. The cruise missiles, once launched, will be opposed by Soviet air defenses, although their low altitude flight paths will make them hard to counter. Failure of their acquisition mechanisms must also be a consideration. Combining both direct attrition and acquisition failures, we estimate a value of 20 percent for cruise missile non-arrival.[2]

It is widely acknowledged that the US is considerably ahead of the Soviets in designing low acoustic signature submarines and in anti-submarine warfare. We suggest, therefore, that there is only a very low probability that cruise missile submarines will be detected and prosecuted while transiting to and from their operating areas. The launch of cruise missiles, however, potentially reveals a submarine's location to Soviet aircraft or other area monitoring systems. This could serve to increase submarine vulnerability. We assume submarine attrition of ten percent following missile launch. Table 6 summarizes these attrition assumptions.

Table 6. ATTRITION ASSUMPTIONS

System	Assumed Attrition (percent)
Surface Ships	0
Carrier Aircraft	1, 5, 10, 20 per sortie
Cruise Missile Aircraft	0
Cruise Missile Submarines	10 per mission (after missile launch)
Cruise Missiles	20

[1]These aircraft could attack interior targets also--an added capability but one that would involve higher attrition.

[2]Bennett, Bruce and James Foster, in "Strategic Retaliation Against the Soviet Homeland" appearing in Cruise Missiles: Technology, Strategy, Politics, by Richard K. Betts, give a 50 percent to 80 percent range (p.158) for cruise missile probability of arrival, but these values include system reliability which we are not considering. We therefore use an arrival probability at the high end of the range.

Figure 2 displays the cumulative cruise missile (or equivalent) delivery capability of the two-carrier battle group and the alternatives. For each number of days d shown on the horizontal axis, d-days of ordnance costs are included in determining the equal cost systems. Thus, the curves in Figure 2 trace capability for alternative planning assumptions rather than the number of cruise missiles delivered over time by fixed numbers of platforms. The analysis supporting Figure 2 is outlined in Appendix B.

Several significant features of Figure 2 stand out, the most important being that, even if one believes that battle groups can survive and operate in high threat areas, they are not appreciably more cost effective than the alternative force options (under our measures) unless carrier aircraft attrition is very low--certainly less than five percent per sortie. Even when carrier aircraft attrition is as low as one percent, systems such as the Cruise Missile Carrier aircraft and the SSGN are more capable on an equal cost basis for planning scenarios lasting a week of so. The CMC retains its advantage over sea-based aircraft until almost 12 days--a considerable length of time to be attacking Soviet targets. Even the SSN-688(VLS), by virtue of the numbers obtainable, dominates carrier aircraft for a short planning horizon even though it is a comparatively inefficient way of delivering ordnance.

It is important to note that the battle group curves shown for five percent and higher attrition rates are somewhat artificial in the sense that battle group operations would likely have ceased long before 30 days because of excessive aircraft losses. At five percent attrition, only ten percent of the attack aircraft would remain by the 30th day--only about two medium attack aircraft and five light attack aircraft. This could be redressed through the use of replacement air wings, but their costs should then also be considered.

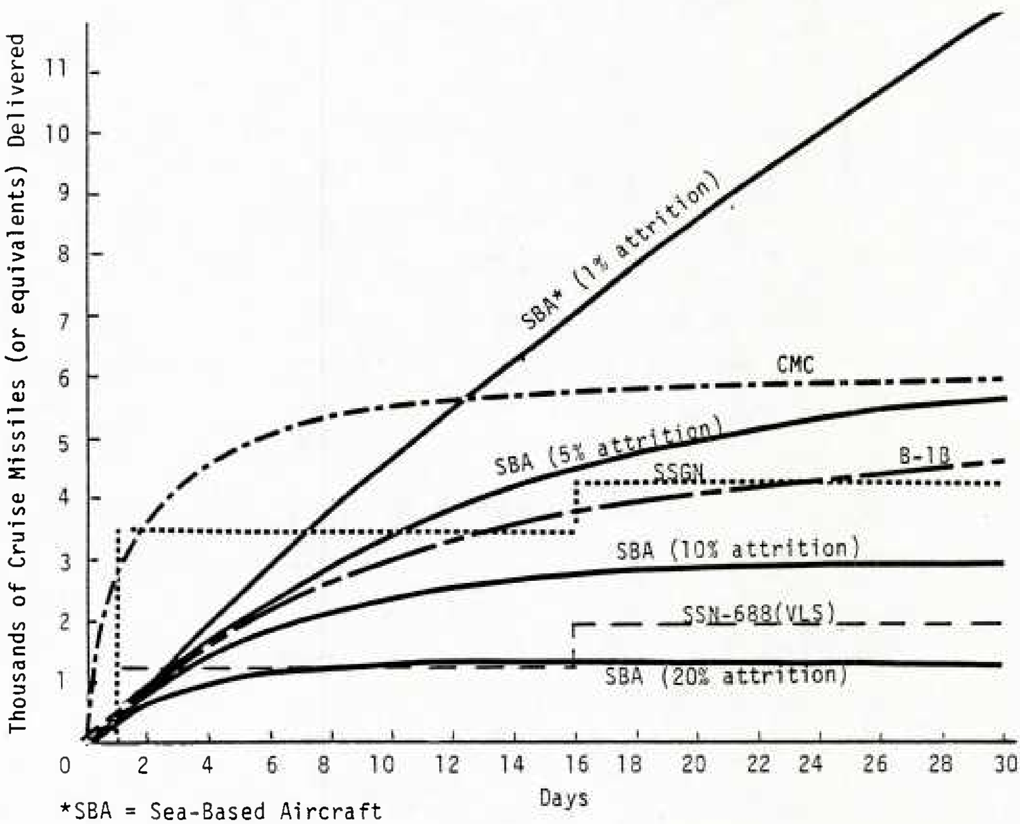

Figure 2. TOTAL CRUISE MISSILE EQUIVALENTS DELIVERABLE AFTER D-DAYS BY EQUAL LCC FORCES (including the costs of d-days of cruise missiles--attrition considered)

As an excursion, it is interesting to compare land-based aircraft with sea-based aircraft when it is assumed that land-based aircraft also suffer attrition. Figure 3 compares the CMC with sea-based aircraft for various attrition rates. Because of the stand-off allowed by its cruise missiles, one would expect that the CMC would suffer less attrition than sea-based aircraft. For very short campaigns, the CMC's large ordnance load makes it preferable to sea-based aircraft at almost any attrition rate. For longer campaigns, the comparison is a little more complex, however, it is evident that if CMC attrition can be kept low, it still dominates sea-based air. For example, for CMC attrition equal to one percent and sea-based aircraft attrition equal to five percent, the CMC is still to be preferred unless the planning scenario exceeds about 28 days, where the two curves cross. (The CMC curves' decreasing portions are a function of the high cost of cruise missiles, of which d-days supply is included in the equal LCC calculations. When attrition is factored in, these missiles represent wasted capability. If the attrition of CMCs was figured into the number of cruise missiles procured, the resulting CMC curves would lie above those in Figure 3. Appendix B contains the equations used to generate the curves in Figure 3.)

6. Conclusions

While no analysis as simple as the foregoing captures all the advantages and disadvantages of the various options, we have demonstrated that there are systems--land-based aircraft and cruise missile submarines--other than carrier battle groups for attacking fixed and known targets in high threat areas that are at least comparable in effectiveness to battle groups on an equal cost basis. Moreover, for reasons we have discussed, we believe that these systems do not share the increasing vulnerability of surface ships in those areas. Therefore, if operations in those areas are vital to US success in a major

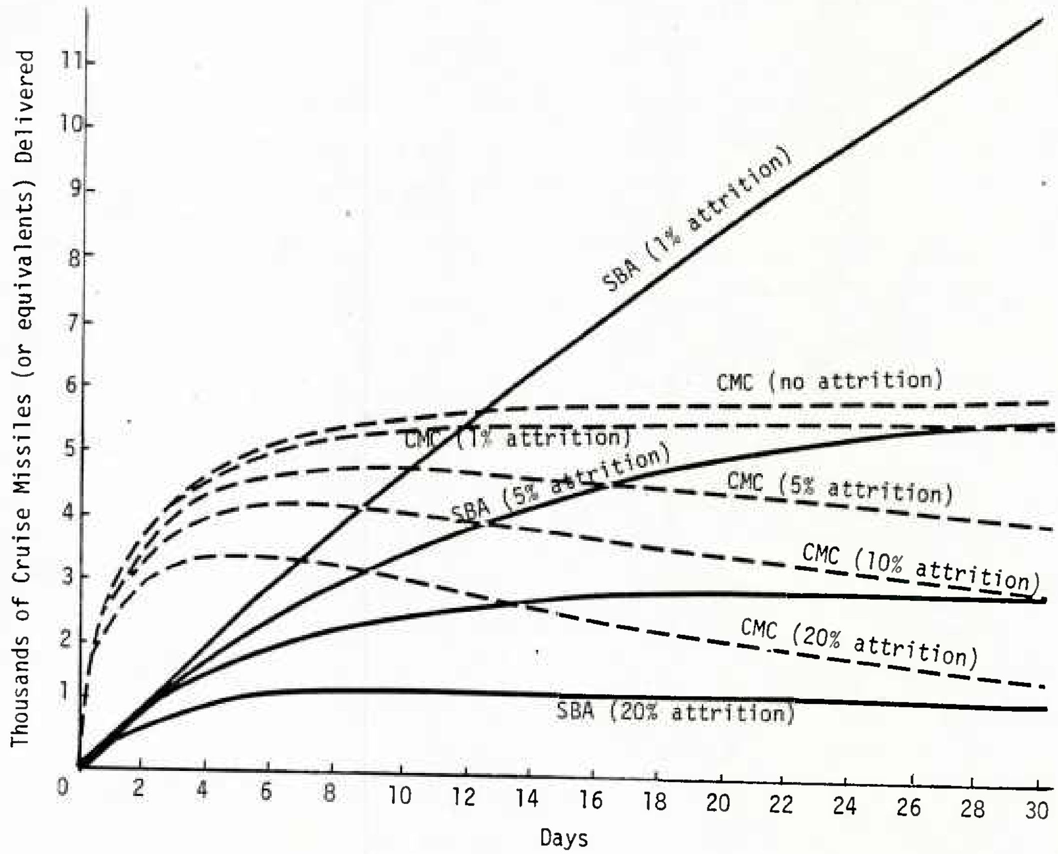

Figure 3. TOTAL CRUISE MISSILE EQUIVALENTS DELIVERABLE AFTER D-DAYS BY EQUAL LCC FORCES OF SEA-BASED AIRCRAFT AND CRUISE MISSILE CARRIERS. VARYING ATTRITION RATES ASSUMED. (Including the costs of d-days of cruise missiles.)

conflict--as the Navy maintains they are for sea control--and if there is doubt about the ability of sea-based aircraft to conduct those operations--which the magnitude of the Soviet anti-carrier threat suggests--then it would seem prudent for the US to procure those alternative systems. Because these systems replace carriers in perhaps their most critical role, it is not unreasonable that some battle groups be foregone to provide funds for their acquisition.

It is true that carriers fulfill other roles and are valuable agents of US strategy during peacetime, crisis, and low-order conflict. The alternative systems, particularly land-based aircraft, also have capabilities to respond to crises and to contribute in lower order conflict (such as the B-52s did in Vietnam). Nevertheless, the flexibility and mobility of aircraft carriers suggest that their usefulness remains, provided they are not required to function in environments in which their survival is doubtful.

If we exclude the surface Navy from the high threat mission through the use of alternative systems, it becomes appropriate to re-examine the low threat requirements of the Navy to resolve how best to satisfy them. This is the subject of the next section.

C. THE SURFACE NAVY AND LOW THREAT MISSIONS

Low threat missions include limited conflict, crisis response and peacetime presence. Common to those missions are reduced overall opposition (compared to the high threat scenarios) although individual opposing systems--aircraft, submarines, or ships--may be quite dangerous, and the need for flexible and credible offensive capability. It is low threat roles that have composed the bulk of the Navy's operations since World War II. Even in conflicts such as Korea and Vietnam, a

significant threat to surface ships never appeared. The Navy, while acknowledging the importance of the low threat missions in the overall spectrum of uses for US military forces, currently minimizes any connection between these functions and force structure, preferring instead to emphasize the war-fighting capabilities of large-carrier battle groups compared to any alternative. The underlying supposition is that whatever is suitable for the most stringent case will perform adequately in lesser contingencies. Putting aside for the moment our concerns about the utility of large carriers in high threat areas, it still does not follow that large-carrier battle groups as structured in the SCFLO are optimal for low threat roles. We believe that it may be possible to identify forces that are superior to such carrier battle groups for low threat roles, and that strong consideration should be given to alternatives to carrier battle groups for low threat roles just as we have for high threat operations.

1. Requirements for Low Threat Roles

Whereas one frequently plans for high threat operations by envisioning a hypothetical conflict--usually a NATO/Warsaw Pact war--for which one's force structure can be optimized, low threat contingencies are marked by many uncertainties. Chief among these uncertainties are (1) the number of areas of the world in which the US may wish to maintain naval presence in the future, (2) the sorts of threats naval task forces will face even in these "low threat" areas, and (3) changes in the political affiliations of third world countries. Needless to say, these all can be expected to vary over time so that flexibility in low threat forces is most important.

Because of this flexibility specification, we will confine our considerations to air-capable ships--aircraft carriers--of various types. The extensive targeting data requirements for

cruise missiles, combined with the relatively small number of fixed, high value targets in those areas in which low-threat operations will likely be conducted, probably limit (but not eliminate) the utility of this type of weapon in this role. Naval gunnery can be useful in areas where targets are at sea or near the shore but here, too, aircraft will be necessary for reconnaissance and early warning.

One candidate, of course, is the Nimitz-class carrier. Such a carrier, combined with nuclear-powered Aegis cruisers for defense against aircraft and submarines, could constitute a quick-reaction task force able to traverse considerable distances at high speed with substantial offensive and defensive capability. The Navy in fact has testified to the usefulness of a task force comprising one Nimitz and as few as two nuclear cruisers for crisis response.[1]

The chief disadvantage of the Nimitz carrier is its high cost. If non-carrier forces intended specifically for high threat operations are to be procured out of Navy funds, as we discussed earlier in this paper, then the Navy cannot also procure large numbers of CVN-centered task forces. Even without the diversion of funds to high threat forces, high CVN costs have led some to suggest that small carriers may be desirable. However, it is generally true that for a fixed budget, as carrier displacement decreases, the number or capability of the aircraft supported is also reduced. Thus, consideration of smaller carriers requires that the advantages of increased

[1]One example given by the Navy occurred in January 1980 when the Nimitz and two nuclear cruisers were sent to the Indian Ocean when a "sudden need for increased U.S. Naval presence...arose." Naval Nuclear Propulsion Program 1981, Hearings on H.R. 2969, Department of Energy Authorization Legislation for Fiscal Year 1982 Before the Procurement and Military Nuclear Systems Subcommittee of the Committee on Armed Services, House of Representatives, Ninety-Seventh Congress, 9 March 1981, p.27.

numbers of ships be weighed against the concomitant reduction in capability as represented by numbers and types of aircraft supported.

Many air-capable ship designs have been proposed by a number of sources, including the Navy itself. Indeed, the Navy acknowledges that small carriers could be useful in low threat contingencies.[1] Table 7 lists several designs that have appeared in open literature and might be candidates for low threat operations, although these are certainly not all possible air-capable ships.[2] Most of the alternatives in Table 7 are basically aircraft platforms with little in the way of additional armament besides the usual point defenses. The Through-Deck Cruiser (TDC) differs in that it is also equipped with guns and missiles for offensive and defensive purposes. The procurement costs for the options listed in Table 7 are from various sources and, in some cases, are only rough estimates. They therefore are not necessarily consistent, but rather only suggestive of the relationship between carrier size and cost.

Note that three of the options would necessarily employ VSTOL aircraft. Existing VSTOL aircraft are range and payload limited compared to current conventional (CTOL) aircraft. The Navy is on record, however, as favoring development of

---

[1]"...smaller, less capable carriers could be utilized individually in low threat scenarios where the total war-fighting capability of a large deck carrier would not be required." Statement of Vice Admiral Wesley L. MacDonald, Deputy Chief of Naval Operations (Air Warfare) before the Committee on Seapower and Force Projection of the Senate Armed Services Committee on the Air Craft Carrier Program, 19 March 1982, p.5.

[2]VAdm MacDonald notes in the aforementioned statement that the Navy has seriously examined more than 45 designs for small carriers.

Table 7. CARRIER OPTIONS FOR LOW THREAT ROLES

Ship Designation	Displacement (Long Tons)	Air Wing	Unit Procurement Cost (Millions of FY82 Dollars)	Remarks
Pure Carriers				
SCS (Sea Control Ship)	14,100[a]	17 Helicopters or VSTOL[b]	440[c]	Austere ship primarily for sea control.
VSS (VSTOL Support Ship)	26,000-29,000[d]	25 VSTOL[e]	980[f]	
LC (Light Carrier)	39,000[g]	35 VSTOL[h] or CTOL	1230[i]	This carrier could support contemporary CTOL aircraft such as the F/A-18, E-2C and S-3A, but not the F-14.[j] Possibly the A-6, modified for STOL operations, could also be accommodated by this carrier.
CVV	62,000[k]	60 VSTOL or CTOL[ℓ]	2252[m]	This ship could operate all current carrier aircraft.[n]
CVN	91,400[o]	90 VSTOL or CTOL[p]	3700[q]	
Air-Capable Ships With Additional Armament				
TDC (Through-Deck Cruiser)	45,000[r]	27 VSTOL[s]	1295[t]	Additional armament includes Harpoon for ASuW, ASROC for ASW, Standard surface-to-air missiles (but AAW weapon system is unspecified), a twin 203mm gun mount and six 76mm guns.[u]

(Footnotes on next page)

Footnotes to Table 7

[a]Department of Defense Appropriations for Fiscal Year 1973, Hearings Before a Subcommittee of the Committee on Appropriations, United States Senate, Ninety-Second Congress, Second Session, Part 3, p.939.

[b]Ibid.

[c]Ibid. The cost of the SCS given in this testimony is \$103.1 million compared to \$797 million for CVN-70 (in then-year dollars). Scaling both ships to FY82 dollars yields about \$440 million for the SCS.

[d]Assessment of Sea-Based Air Platforms Project Report, Office of the Secretary of the Navy, Department of the Navy, Washington, D.C., February 1978. The higher figure is for a design with greater passive defenses.

[e]Ibid. We use the midpoint of the 24 to 26 aircraft range indicated.

[f]Department of Defense Appropriations for Fiscal Year 1976, Hearings Before a Subcommittee of the Committee on Appropriations, United States Senate, Ninety-Fourth Congress, First Session, Part 3--Department of the Navy. Page 330 of this testimony presents VSS designs with slightly greater displacement than the one we present. Based on the costs presented there, we estimate the ten-year follow-ship procurement cost of the VSS to be about \$400 million in FY76 dollars. This compares with \$180.2 given for the SCS in the same testimony. Using the \$440 million in FY82 dollars already derived for the SCS, adjusting the VSS cost to FY82 dollars yields about \$480 million.

[g]Department of Defense Authorization for Appropriations for Fiscal Year 1981, Hearings before the Committee on Armed Services, United States Senate, Ninety-Sixth Congress, Second Session, Part 2, p. 1102.

[h]Ibid.

[i]Ibid. Cost figures are not given, but the Navy's goal "...is one-third the price of a CVN in the year of authorization." We use \$3.7 billion for CVN unit cost.

[j]Ibid.

[k]Department of Defense Authorization for Appropriations for Fiscal Year 1982, Hearings Before the Committee on Armed Services, United States Senate. Ninety-Seventh Congress, First Session, Part 4--Sea Power and Force Projections, p. 2038.

[ℓ]Ibid.

[m]Ibid.

Footnotes to Table 7 (continued)

[n]Full Committee Consideration of the CVV Program. Committee on Armed Services, House of Representatives, Ninety-Fifth Congress, First Session, May 24, 1977, p.9.

[o]Jane's Fighting Ships, 1977-1978, Moore, John E., ed., p.570.

[p]Ibid.

[q]Mitchell, Douglas, D., Shipbuilding Costs for General Purpose Forces in a 600-Ship Navy, Congressional Research Service Report 82-23F, February 16, 1982, p.CRS-20.

[r]Cairl, Michael A., "Through Deck Cruiser: The New Capital Ship," U.S. Naval Institute Proceedings, December 1978, p.39.

[s]Ibid. A range of 25-30 aircraft is specified.

[t]Ibid. The cost is specified as "35% of the cost of [a] nuclear-powered carrier."

[u]Ibid.

more capable VSTOL aircraft.[1] If this development is carried out, the smaller options become feasible. We will evaluate the smaller options assuming this development can be satisfactorily completed.

In this section, we explore approaches to quantifying the relative merits of the various types of carriers listed in Table 7. Three separate investigations are conducted. In the first, we examine the relationship between numbers of separately deployable task forces--which are necessary for simultaneous peacetime deployments--and aggregate capability. We will demonstrate how, when costs are fixed, capability falls off as numbers of task forces are increased through the procurement of smaller, less expensive carriers.

The second investigation analyzes a simplified low-order conflict to address the "all-the-eggs-in-one-basket" question; that is, whether or not dispersed forces are better able to maintain capability than a concentrated force. This is a frequently mentioned argument in favor of smaller carriers.

In the final section, we briefly look at how defensive and support aircraft requirements may set lower limits on feasible carrier size.

It is necessary to acknowledge at the outset of these analyses that many important characteristics of naval forces are not necessarily quantifiable, and this is particularly true in the context of the low threat where perceptions may

---

[1] "I think it fair to say we expect V/STOL aircraft would be more expensive because of the development costs but that the tradeoff and improvement in tactical applications would add to the effectiveness part of the cost and effectiveness equation such that we would be well advised to put our funds and efforts in that development.", Vice Admiral F.C. Turner, Deputy Chief of Naval Operations (Air Warfare), testifying before the Senate Armed Services Committee, April 21, 1978. Department of Defense Authorization for Appropriations for Fiscal Year 1979, Hearings Before the Committee on Armed Services, United States Senate, Ninety-Fifth Congress, Second Session, Pt.7--Tactical Air, p.5453.

play as large a role as the effectiveness of hardware. Nevertheless, quantitative approaches are particularly useful in making explicit the underlying assumptions that are often only implicit in discussions of the relative merits of alternative naval force structures.

Before proceeding further, it will be convenient to fix, for analytical purposes, the level of resources to be devoted to low threat uses. In the Introduction, we established that 15-battle groups represented $756 billion in 30-year life cycle cost. In Section B we argued that, in an alternative force structure, it would be appropriate for part of this sum to go for alternative forces for high threat areas. The remainder, therefore, under our conceptual separation of high threat and low threat forces, goes for the latter. To properly set the dividing line goes far beyond this paper in that it requires detailed assessments of Soviet capabilities and US strategy. But for the purpose of this paper, let us assume that the Navy intends to employ no fewer than six of its fifteen carrier battle groups in high threat operations; perhaps four in the Norwegian Sea and/or Eastern Mediterranean, and another two in the northwest Pacific. Accordingly, we will reserve 6/15 of the $756 billion for high threat forces, leaving 9/15, or $454 billion for low threat purposes.

A desirable characteristic of a naval force structure is the ability to deploy ships on a continuous basis to areas of the world of strategic importance to the United States. Currently, the US maintains presence in three areas of the world: the Mediterranean, the Western Pacific, and, more recently, the Indian Ocean. Higher commitments in these areas in the future are clear possibilities. In addition, other areas of the world are beginning to demonstrate the sorts of instabilities that may elicit requirements for US naval presence. Central and South America come immediately to mind, but other areas, such

as Africa, could also require our attention. Accordingly, numbers of separately deployable task forces appear desirable. However, numbers by themselves are not a sufficient criterion by which to judge a force structure. The ships that are deployed must have "credible" capability by some measure of capability. Thus, the greater numbers of smaller carriers available for a given budget must be weighed against the greater capability of the fewer, but more effective, larger carriers.

We begin by determining how many separately deployable task forces could be procured and operated for the $454 billion we set aside for low threat purposes. This will depend on the type of carrier used, the number of escorts accompanying each, and the underway replenishment required by each type of task force.

While it is true that task force composition is not fixed but is determined by the requirements of a particular situation, it is nonetheless convenient, for planning purposes, to specify a notional task force, much as the Navy does with the SCFLO. It is therefore necessary to specify the numbers and types of defensive escort ships per task force for low threat operations. The uncertainties inherent in predicting future requirements, the possibilities for escalation and the capabilities of potential opponents make this determination a problem of substantial proportions.

We will assume that two highly capable escorts are sufficient, for planning purposes, for a task force intended for low threat contingencies. These escorts will, however, need to provide sophisticated capabilities against antiship missiles and submarines--both increasing and dangerous threats even in low threat areas. Accordingly, for all air-capable ships other than the CVN, we employ as escorts the projected 8500 ton DDG-51 destroyer, which will have a version of the advanced Aegis air defense system as well as modern ASW equipment. For

the CVN, we specify two nuclear-powered, Aegis-equipped CGN-42 cruisers in order to complement the CVN's nuclear propulsion.[1] All of these escort ships have more advanced weapon suites than the two escorts sent with the Nimitz in 1980.

We make an exception to the two-escort premise for the Through-Deck Cruiser, which, because it carries some of its own air defenses such as surface-to-air missiles, only requires (we assume) one escort.

We note finally that while we assume two escorts per carrier (except for the Through-Deck Cruiser) independent of carrier size, justifications exist for varying escort levels either down or up with carrier size. One point of view might decrease escort levels with decreasing carrier size in an attempt to keep the ratio of task force offensive to defensive capability constant. On the other hand, others might argue that the increased vulnerability of smaller ships and their reduced ability to support numbers of defensive aircraft require increased numbers of escorts for small carriers. Our approach lies between these.

We will call these combinations of ships low-threat task forces (LTTFs). Table 8 summaries the 30-year life cycle costs of the various LTTFs. Table 9 displays the numbers of LTTFs that could be procured and operated for 30 years for the $454 billion that we have allocated for low-threat purposes.

If numbers of sea-based aircraft were the only criterion, it is clear that the LTTFs would be ranked in the order shown in Table 9. Moreover, since the larger carriers can handle larger and more capable aircraft, the inclusion of an assessment of aircraft capability would further support the ordering

---

[1]While it may appear that we are biasing our costs against the CVN task force by including relatively expensive nuclear escorts, substituting the less expensive DDG-51s (and appropriately increasing underway replenishment costs) would lower the life cycle cost of the CVN task force by only about six percent.

Table 8. LIFE CYCLE COSTS OF ALTERNATIVE LTTFs (Percentages of Line Totals in Parentheses)

	Ship Cost[a]	Air Wing Cost[b]	Defensive Escort Cost[c]	Underway Replenish-ment Cost[d]	Total Cost
	Millions of FY 1982 Dollars				
CVN	11100(26)	19800(46)	6700(16)	5526(13)	43126
CVV	6750(23)	13200(44)	3552(12)	6378(21)	29880
LC	3690(19)	7700(41)	3552(19)	4059(21)	19001
TDC	3900(24)	7425(45)	1776(11)	3482(21)	16583
VSS	2940(18)	6875(42)	3552(22)	3052(19)	16419
SCS	1320(11)	4675(40)	3552(30)	2105(18)	11652

[a] Carrier life cycle cost is assumed to be three times the unit procurement cost shown in Table 7 (see Appendix A).

[b] Air Wing life cycle costs are the product of the number of aircraft and an average life cycle cost per aircraft of $220 million (the average life cycle cost per sea-based aircraft in a CVN air wing as computed in Appendix A). The costs of those air wings that are restricted to VSTOL aircraft only are increased by 25 percent. This latter figure comes from testimony before the Senate Armed Services Committee on April 12, 1978, by RADM D.F. Mow, then the Navy's VSTOL program coordinator who remarked that it was unlikely that VSTOL 30-year life cycle costs would exceed CTOL costs by more than 25 percent. This penalty is applied only to the SCS, the VSS and TDC ships. The others could employ CTOL aircraft.

[c] The life cycle costs of two DDG-51 escorts were charged to all ships except the TDC which we assume requires only one escort, and the CVN, which is accompanied by two CGN-42 class ships which we assume have a life cycle cost of $3.34 billion each.

[d] Underway replenishment costs are estimated using the values presented in Appendix A. In that analysis, $723 billion in underway replenishment assets were ascribed to a two-carrier battle group containing about six conventionally powered ships and 90 aircraft. We assume that propulsion and aviation fuel drive replenishment costs. Of petroleum used by the Navy for ships and aircraft, ships use about 52 percent of the total, aircraft about 48 percent (Collins, Frank C., "Energy: Essential Element of National Security," U.S. Naval Institute Proceedings, December 1980.) The Navy operates ships totalling about 5,400,000 tons displacement (Jane's Fighting Ships 1977-78) and about 2700 Navy and (continued on next page)

[d](continued) Marine Corps aircraft (The Military Balance, 1981-82) so that if underway replenishment requirements for ships scale proportionally to displacement, each 1000 tons of displacement accounts for about .010 percent of the fuel required by ships aircraft, while each aircraft accounts for about .018 percent. In other words, each aircraft equals about 1.8 kiloton of displacement in terms of underway replenishment requirements. In the battle group cited, therefore, 90 aircraft account for 162 kilotons of displacement while the conventionally propelled escorts account for only about 49 kilotons of displacement. Therefore each displacement kiloton costs about $34.1 million in 30-year replenishment costs, each aircraft about $61.4 million. These calculations are, of course, very crude but we believe them adequate for our purposes.

Table 9. NUMBERS OF LTTFs FOR $454 BILLION

Air-Capable Ships	Number of LTTFs Obtainable	Total Sea-Based Aircraft
CVN	10.5	945
CVV	15.2	912
LC	23.9	836
TDC	27.4	740
VSS	27.7	692
SCS	39.0	663

of Table 9. However, if we desire numbers of forward deployable units in order to maximize the capability of the force structure to establish presence in different areas, then the ranking of Table 9 would be reversed. Although the pure CVN force ranks high in aggregate sea-based aircraft, only about three CVN LTTFs can be maintained on station, assuming that one LTTF can be maintained forward for each three in inventory.[1] If more are needed, either because more maritime areas require presence, other types of LTTFs are required. Table 10 lists mixes of LTTF types that maximize deployed (as well as total) sea-based aircraft and also satisfy given forward deployment levels and the $454 billion cost constraint. Note how, as the number of required deployments increases, the greater the representation of the smaller carriers. Note also the tradeoff between deployments and total deployed sea-based aircraft. Each additional task force deployment results in an aircraft reduction of from three to five percent.

[1]There are indications that this ratio is somewhat optimistic, especially for deployments distant from US ports. This value is often cited, however, and we use it here for convenience. This reader should be cautioned that one-in-four or one-in-five might be more realistic.

Table 10. MIXES OF LTTFs THAT SATISFY PRESENCE REQUIREMENTS AND MAXIMIZE TOTAL SEA-BASED AIRCRAFT (Equal 30-Year Costs)

Deployments	Type LTTFs (Total Inventory)						Total Forward Deployed Sea-Base A/C
	CVN	CVV	LC	VSS	TDC	SCS	
1	10.5						315
2	10.5						315
3	10.5						315
4	7.2	4.8					312
5	0.4	14.6					304
6		10.3	7.7				296
7		5.1	15.9				287
8			23.7			0.3	278
9			19.0			8.0	267
10			14.2			15.8	255
11			9.5			23.5	244
12			4.7			31.3	232
13						39.0	221

It is clear that there is a balancing of risks involved in the choice of numbers and types of task forces under any budget constraint. If total aircraft do indeed represent, even in a crude way, the capability of a force structure, then one can have a relatively few, highly capable task forces and risk not having enough to meet worldwide requirements (as the Navy feels is now the case), or one can have an abundance of less capable units and run a higher risk of, if not defeat, then lowered effectiveness in certain situations. It is worth noting, however, that numbers of small-carrier task forces allow for the augmentation of forces in a particular scenario with greater ease, while a few large-carrier task forces cannot be dispersed to more areas than there are such task forces.

The mixes in Table 10 are by no means the only rational ones. For example, one could satisfy a five deployment requirement with the approximately 15 CVV fraction of a CVN mix as shown in the Table or with a seven CVN, eight LC mix. While "nonoptimal" in that fewer aircraft are supported, the difference is miniscule (303 aircraft vs 304 for the Table 10 mix) and, in fact, the CVN/LC mix might be optimal when integer requirements are imposed. Even if that were not the case, the advantages of a mix consisting of almost 50 percent nuclear task forces, with their relative freedom for logistic constraints, might well outweigh the overall loss of aircraft support that is a consequence of the LC component of this mix, which is necessary to keep life cycle costs to the level we have determined.

The determination of the minimum necessary number of deployments is a matter to be decided at high policy-making levels within government, just as the total expenditure of naval forces is a function of many factors, not all of which directly relate to measurable naval capability. Certainly, the weighing of alternative risks such as discussed in the previous paragraph must be a part of that process. Once budgets and numbers have been determined, however, then unless adequate numbers of large-carrier CVNs can be procured and operated, smaller ships must enter the picture, either as large-carrier replacements, or, as is sometimes the case in Table 10, in a high-low mix with large carriers. (Note that mixes of carrier types are the rule in Table 10 rather than the exception.)

2. Survivability

Another issue often raised in discussions of large versus small carriers is the issue of vulnerability. The Navy maintains, and there is no reason to doubt, that in a ship-by-ship comparison larger ships can, through the incorporation of greater numbers of active and passive defensive systems, be

made less vulnerable to a given attack size than smaller ships. Hence a small-carrier LTTF, as described in the previous section, would be less survivable than, say, an LTTF built around a Nimitz-class carrier. Moreover, with fewer aircraft, a small-carrier LTTF might be less able to inflict damage on an attacking force; that is, the price paid by an opponent attacking a small-carrier LTTF might be less than against a Nimitz-based LTTF. However, multiple small-carrier LTTFs would place a greater reconnaissance burden on an unsophisticated opponent than fewer large-carrier LTTFs. Whereas the Soviets would have less trouble determining the whereabouts of several small-carrier task forces--unless the US took deliberate deceptive actions against their ocean surveillance system--a typical low threat opponent would have to sequentially search out and attack each of however many LTTFs are present. While the probability of finding any task force in a given time period generally increases as the number of task forces in the vicinity increases, the damage suffered by the attacker while attacking a task force may reduce its ability to attack the next. Accordingly, proponents of small carriers sometimes cite the survivability advantages of dispersed air power as one important justification of a small-carrier force structure.

One way to investigate the validity of these competing assertions is simply to simulate these forces in an idealized campaign to determine which claims are borne out and which are not. We therefore built a simple--and highly stylized--Monte Carlo computer model. It was based on the following assumptions:

(1) A multi-day campaign is occurring in which a number of LTTFs is in an operating area supporting sea-based aircraft operations. Meanwhile, an opponent sequentially seeks out and attacks LTTFs. We will not specify the nature of these opposing forces--one can imagine ships, aircraft, or submarines--but we assume that they concentrate on one LTTF at a time and, in attacking an LTTF, suffer some degree of degradation.

(2) If one LTTF is present, one day is required to find and mount an attack on it. If n LTTFs are present ($n \geq 2$), then 1/n day is required to find one of them and to attack it. Thus, putting more LTTFs in an area simplifies an opponent's reconnaissance problem--it is easier to find one of a large number of task forces than one of a few.

(3) The first attack on any task force puts it out of action with probability (p). By "out of action," we mean that its aircraft no longer contribute to the overall effectiveness of the LTTFs. This assumption implicitly credits the attackers with being able to identify and target the air-capable ship in a task force--something that, in reality, may not be so easy. We do not allow situations in which the escorts are damaged but the air-capable ship still functions.

In performing this attack, the attacking force suffers a degradation in capability (a) whether or not the task force is put out of action, so that the next attack mounted by the opposition puts the targeted LTTF out of action with probability $p(1-a)$. This process compounds, so that a third attack, if it occurs, is effective with probability $p(1-a)^2$, and so forth.

(4) A task force that is put out of action is identifiable as such by the opponent, so that the time required for him to find the next functional task force increases as specified in paragraph (2) above.

(5) This process continues until no task forces remain or until some predetermined time limit expires.

(6) The measure of merit of a number of task forces, given the values of (p) and (a), is the expected number of sea-based aircraft remaining after a given number of days.

It is important to emphasize that this scenario is only one of many possible. It nevertheless contains the essential elements of a naval campaign and we therefore feel that the results generated with this model are informative. Appendix C provides the results that this model predicts for ten days of operations when the number of task forces varies from one to four and for various values of (p) and (a).[1]

[1]Some readers may recognize the continuous analog of this to be essentially a classical Lanchester linear process. Use of the exact solutions to the continuous approximation yields conclusions very similar to those obtained through the discrete Monte Carlo model.

The results of this analysis can be used to compare alternative carrier task forces to CVN task forces as illustrated in Figure 4. This figure, which displays the numbers of LTTFs and total 30-year life cycle to a single CVN LTTF, shows three lines. Each line compares the alternatives to the CVN LTTF by dividing the space of task force numbers and total aircraft into two regions. Above each line are combinations that are superior to the CVN task force--in terms of surviving aircraft after ten days--for the values of (p) and (a) that the line represents. Below each line are those combinations that are inferior to the CVN task force.

We assume in Figure 4 that the alternatives are less survivable and less capable of degrading the attacking forces than the CVN task forces. Therefore, for given values of (p) and (a) for the CVN force, we assume that each smaller-carrier task force is put out of action (by the first attack) with probability (p+0.1) while the attacking force is degraded by a factor (a-0.1) following such an attack. The increase in out-of-action probability is warranted by both the somewhat less capable escorts assumed for the alternatives as well as the reduced survivability of the air-capable ship that we have previously alluded to. The alternative carriers' decreased abilities to degrade the attackers might stem from reduced ability to support numbers of fighters or other defensive aircraft as air wing sizes decrease. While we believe both assumptions are reasonable, the increment chosen--±0.10--is arbitrary. The three curves shown in Figure 4 are the following values of (p) and (a) (for the CVN task forces):

1. p = 0.2; a = 0.2
2. p = 0.2; a = 0.5
3. p = 0.2; a = 0.8.

The out-of-action probability--0.2--represents a low-threat environment where the opposition has a one in five chance to

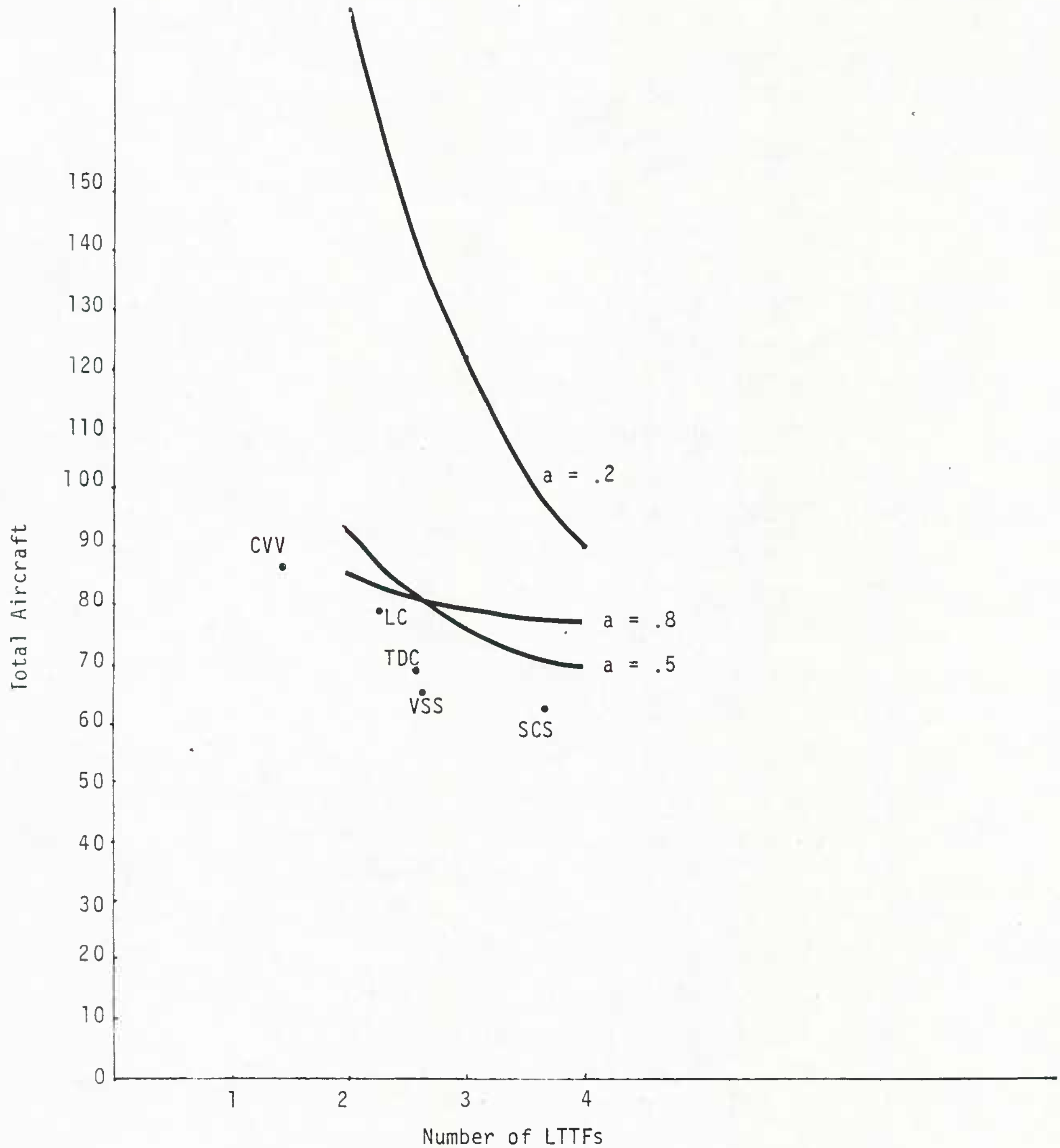

Figure 4. LINES SEPARATING OPTIONS SUPERIOR TO 1 CVN LTTF FROM THOSE INFERIOR TO 1 CVN LTTF FOR p = 0.2, a = 0.2, 0.5, AND 0.8 (see text for further assumptions)

eliminate a CVN LTTF with undegraded attackers. The three values of (a) parametrically investigate low, medium, and high attacker vulnerability to task force defense. What is notable is that all the LTTF alternatives lie below all three lines. (The C_V is an exception since only from two to four LTTFs are analyzed. It appears, however, that the CVV would lie under any of the lines if extended.) In other words, the loss in aircraft numbers as the number of task forces increases is not adequately compensated for by the dispersion of the aircraft into numbers of task forces, even though that dispersion forces the opponent to search for each task force and attack it individually.

For comparison purposes, Figure 5 shows similar curves for p = 0.7 for the CVN LTTF. While such a high (p) belies supposition of a low threat, Figure 5 does illustrate that there do indeed exist conditions under which small carrier LTTFs are superior to LTTFs on an equal-cost basis using this measure of effectiveness. However, the results from Appendix C, as typified by Figures 4 and 5, suggest that alternative LTTFs will dominate the CVN LTTF chiefly in high-threat areas rather than in low-threat areas--areas in which, we have already argued, types of systems other than surface ships may be preferable.

A more detailed simulation combined with accurate data might help to fine-tune these comparisons. As long as the basic components of the foregoing analysis are retained, we feel that the same conclusions will be reached; viz, that in low-threat areas, alternative-carrier task forces appear less effective than CVN task forces in terms of preserving, on an expected value basis, numbers of aircraft for a given period of time. At any rate, the suggested advantages of multiple task forces are not obvious given the reduced capability, increased ship vulnerability, and the increased likelihood of detection that are corollaries of dispersion.

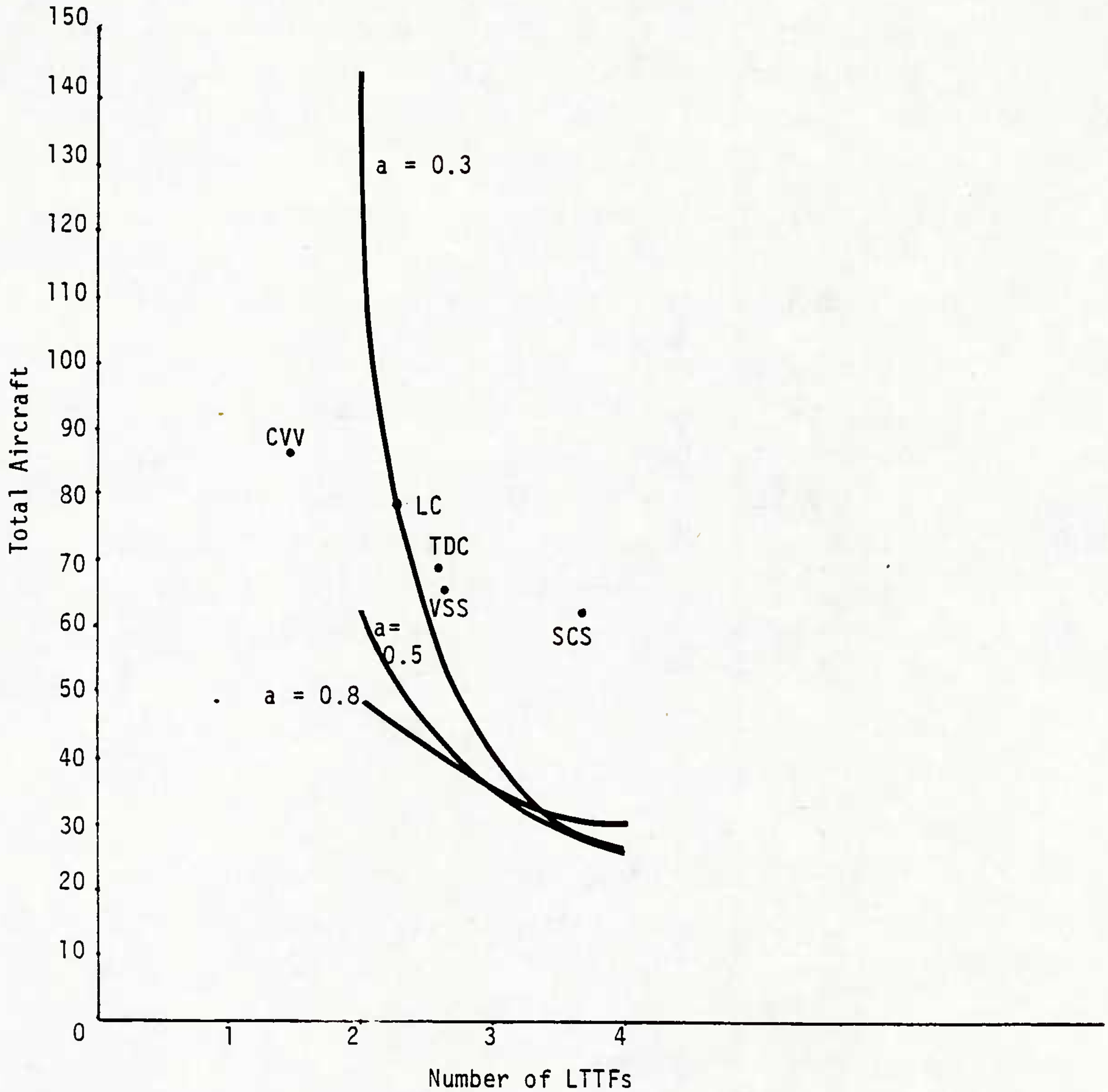

Figure 5. LINES SEPARATING OPTIONS SUPERIOR TO 1 CVN LTTF FROM THOSE INFERIOR TO 1 CVN LTTF FOR p = 0.7, a = 0.3, 0.5, AND 0.8 (see text for further assumptions)

Of course, such an expected value approach does not capture all of the probabilistic aspects of this type of stylized campaign. Table 11 gives the probability-of-survival distributions for the three cases shown in Figure 3. Note that while the highest probability that all task forces will be put out of action occurs when there is only one present, so also does the highest probability that no carrier will be put out of action. What multiple task forces allow is the possibility of intermediate cases: for example, 1 out of 4 or 2 out of 4 or 3 out of 4 carriers surviving. Viewed in this light, the CVN LTTF offers the best chance of retaining full capability while the alternatives offer higher likelihoods of preserving some capability. One's preference under those conditions depends very much on one's attitude or risk and the acceptability of losses of even small-carrier task forces.

Table 11. PROBABILITY THAT EXACTLY X CARRIERS SURVIVE OUT OF Y* AFTER 10 DAYS

X	p=0.2 a=0.2	p=0.3 a=0.1 Y			p=0.2 a=0.5	p=0.3 a=0.4 Y			p=0.2 a=0.8 Y	p=0.3 a=0.7 Y		
	1	2	3	4	1	2	3	4	1	2	3	4
0	.65	.62	.45	.23	.38	.18	.03	.00	.24	.04	.00	.00
1	.35	.32	.30	.32	.62	.34	.13	.02	.76	.37	.04	.01
2		.06	.20	.28		.48	.44	.12		.60	.34	.03
3			.05	.12			.40	.40			.62	.38
4				.04				.47				.58

*Expected values calculated from this table will vary slightly from those shown in Appendix C due to the normal variations from run to run in Monte Carlo simulations. Probabilities may not sum to unity in columns due to rounding.

Before ending this section we should note a salient limitation of this analysis, namely, that the notional attrition campaign analyzed above does not allow investigation of any tactical advantages that may reside in greater numbers of ships--such as the ability to conduct offensive operations in widely separated regions. While this may or may not be a useful tactic--it counters the generally held notion that it is good to concentrate one's forces--the operational flexibility allowed by multiple task forces may be valuable or even critical under certain conditions. Conversely, multiple LTTFs introduce coordination problems that, unless overcome, could result in capability degradations in addition to those imposed by the smaller numbers of aircraft.

3. Air Wing Requirement

A final way of sorting out these carrier options is to begin building the air wing "from scratch" to determine the minimum number of aircraft needed to perform effectively the offensive and defensive functions that are necessary to the effective use of a carrier task force. These functions include anti-air warfare, anti-surface warfare, anti-submarine warfare and land attack. Let us begin by examining the typical CVN air wing (Table 12).

Table 12. TYPICAL CVN AIR WING

Number	Type	Purpose
10	A-6	Attack
24	A-7E	Attack
24	F-4/F-14	Fighter-escort/ interceptor
4	E-2C	Airborne early warning
4	EA-6B	Electronic warfare
4	KA-6D	Tanker
3	RF-4/RF-14	Reconnaissance
10	S-3	Anti-submarine warfare
6	SH-3	Anti-submarine warfare

Given the proliferation of aircraft armed with air-to-surface missiles, the airborne early warning mission is a vital one--one that will have to be performed round the clock. Thus, the four E-2Cs seem a minimal number. Similarly, the three reconnaissance aircraft do not seem excessive.

Anti-submarine aircraft will also be a crucial component of any task force air wing. There are potential opponents in all areas of the world with at least a few submarines.[1] Since even a single submarine penetrating a task force can cause great damage, effective ASW screens are necessary to deter or thwart such a penetration. How many aircraft are needed for this may be an important driver of air wing size. Because modern diesel-electric submarines, such as might be encountered in some low-threat scenarios, can be extremely difficult to detect when operating on battery--more so than some Soviet nuclear submarines--it is not evident that the ASW component of the CVN air wing can be appreciably reduced. Further, the reduced number of surface escorts we have assumed for the LTTFs suggests that a greater proportion of ASW defense must be borne by aircraft rather than ships. For those reasons, it is not clear that the 15 ASW fixed wing aircraft and helicopters can be appreciably reduced. Let us assume, however, that 75 percent of the ASW component of the CVN air wing is sufficient for low threat ASW.

So far we have 17 aircraft. Retain two of the four tanker aircraft to facilitate deck operations and we are up to 21. We must now consider attack and fighter aircraft. The CVN carried five squadrons of such aircraft. If we envision a dual purpose aircraft, such as the F/A-18, a single squadron of fighter/attack aircraft might suffice. This would raise the total to 33 aircraft. If this is an accurate lower bound on useful air

---

[1] Among the submarine-owning countries not aligned with NATO or the WP are Albania, Yugoslavia, Egypt, Libya, South Africa, China, Taiwan, India, Indonesia, North Korea, Pakistan, Argentina, Brazil, Chile, Colombia, Cuba, Ecuador, Peru and Venezuela (IISS-The Military Balance 1981-1982, passim.)

wing size, then the TDC, VSS, and SCS have been eliminated as feasible designs for independent operation. Thus, if multiple capabilities are required in an LTTF air wing, larger carrier designs may be required simply to support the minimum numbers of aircraft required. Observe that combining these smaller carriers into multi-carrier task forces in order to support the required numbers of aircraft defeats the purpose of considering those alternatives, which is to provide numbers of independently deployable task forces.

To some extent, the smaller carriers could re-enter the running if they utilized multipurpose aircraft that could be configured for different operations onboard ship. The F/A-18 is an example, easily switching between fighter and attack roles. Conceivably, multipurpose aircraft for the other roles also could be developed.[1] Specialized air wings for those contingencies wherein certain missions could be ignored or left to other forces (for instance, airborne early warning could be performed by land-based aircraft--AWACS--in some parts of the world) also might permit greater offensive capability on the small (as well as large) carriers.

4. Discussion

For the types of low threat situations most likely to involve naval forces in the future, considerations of tactical flexibility and worldwide mobility point to the continued usefulness of sea-based air power and, consequently, to the air-capable surface ship. The choice of carriers for these purposes depends on (1) current and projected budgets to be earmarked

[1]A common subsonic airframe is envisioned by the Navy's VSTOL Master Plan for many of these defensive missions. More than just a common airframe is necessary, however. If all these defensive tasks are necessary, the ability to quickly configure the basic aircraft for the missions seems imperative.

for low-threat forces, (2) minimum numbers of units necessary to fulfill US objectives, and (3) minimum capability levels to meet reasonable low-threat contingencies.

The selected analyses we have presented, which by no means exhaust the issues that need to be considered for low-threat force structuring, tend to point to the desirability of carrier task forces built around large carriers insofar as they are affordable. These large-carrier task forces need not necessarily incorporate the extensive defensive escort stipulated by the Navy's Surface Combatant Force Level Objective, however. Smaller carriers or other air-capable ships such as the part carrier/part cruiser Through-Deck Cruiser appear useful chiefly to generate numbers of separately deployable task forces. These offer the opportunity to establish presence in multiple areas but, when compared to large CVN-type carriers on an equal cost basis, suffer from reduced capability. Moreover, the survivability of small-carrier task forces does not appear noticeably superior to large-carrier task forces under the low threat conditions we have stipulated.

While any move away from large carriers to a greater number of smaller ships appears to result in an overall reduction in naval capability, one should not discount the potential of even a small-carrier task force to dissuade an adversary from taking hostile steps. Retired Admirals Elmo Zumwalt and Worth Bagley have suggested[1] that "preliminary analysis of the resources Britain required to retake the Falklands suggest that about 6 percent of that fighting power, if deployed to the Falklands early in 1982, could have discouraged Argentina from its attacks." If small-carrier presence can indeed prevent the need for actually applying military force to the degree suggested above, then the apparent loss in capability resulting

---

[1]Zumalt, Elmo, and Worth Bagley, "Lessons for Future Deterrent Strategies," The Washington Times, July 15, 1982.

from a move to smaller carriers would be more than compensated for by their ability to deter conflict in simultaneous areas.

In the next section, we suggest how all these considerations might be combined and suggest directions for Navy planning.

D. CONCLUSIONS

Table 13 summarizes the observations of the previous two sections. For high threat operations--where one risks massed attacks by Soviet land-based bombers, possibly in combination with cruise missile submarines, and where the potential for nuclear anti-carrier attacks must be considered, a restructuring of US naval forces to include long-range land-based interceptor and strike aircraft and cruise missile submarines would provide offensive capability comparable to carrier battle groups on an equal cost basis (as shown in Section B) and would also provide better survivability, even under some nuclear warfare scenarios. Surface ships are distinctly inferior to these alternatives because of their vulnerability, but we rank small carriers above large carriers since the simple campaign model of Section C suggests that when out-of-action probabilities are high, dispersing aircraft over a number of decks may allow capability to endure longer than if it were concentrated.

For low threat areas, the ranking is reversed. Against the sorts of threats to be encountered here, large carriers are survivable, flexible and in the long run, are a more cost-effective way to attack targets than are submarines or land-based aircraft operating from distant bases. Small carriers are less desirable than large carriers because of their less efficient support of aircraft and because they are less survivable. They share with large carriers the virtues of flexibility and mobility, however, and become necessary if numbers of surface task forces are to be procured.

Table 13. RANKINGS OF NAVAL FORCE STRUCTURE OPTIONS

High Threat
(Major Conflict Within Soviet Homewaters)

Rank	Category	Roles	Advantages	Disadvantages
1.	Long Range Land-Based Aircraft	• Anti-Air Warfare • Anti-Surface Warfare • Anti-Submarine Warfare • Land Attack	• Long range allows survivable rear basing • Stand-off weapons reduce attrition	• Geographically Constrained
1.	Submarines	• Anti-Surface Warfare • Anti-Submarine Warfare • Land Attack	• Geographically mobile • Subsurface operation enhances survivability	• No Anti-air capability • Low weapon delivery rates • Difficult to mass forces • Communication & coordination difficulties
2.	Small Aircraft Carriers	• Anti-Air Warfare • Anti-Surface Warfare • Anti-Submarine Warfare • Land Attack	• Geographically mobile • Cost permits enlarged fleet sizes • Dispersed capability complicates attackers' problem	• Questionable survivability • Reduced numbers and capability of sea-based aircraft
3.	Large Aircraft Carriers	• Anti-Air Warfare • Anti-Surface Warfare • Anti-Submarine Warfare • Land Attack	• Geographically mobile • Efficient support of high technology aircraft	• Questionable survivability • High cost limits fleet size

Low Threat
(Low Order Conflict, Crisis Response, Presence)

Rank	Category	Roles	Advantages	Disadvantages
1.	Large Aircraft Carriers	• Anti-Air Warfare • Anti-Surface Warfare • Anti-Surmarine Warfare • Land Attack • Presence	• Geographic Mobility • Efficient support of high technology aircraft • Good survivability • Flexible Operations	• High cost limits fleet size
2.	Small Aircraft Carriers	• Anti-Air Warfare • Anti-Surface Warfare • Anti-Submarine Warfare • Land Attack • Presence	• Geographic Mobility • Lower Cost permits enlarged fleet size • Flexible Operations	• Higher vulnerability than larger ships • Reduced numbers and capability of sea-based aircraft
3.	Long Range Land-Based Aircraft	• Anti-Air Warfare • Anti-Surface Warfare • Anti-Submarine Warfare • Land Attack	• Long range allows area coverage • Can employ relatively inexpensive ordnance	• Geographically constrained by basing requirement • Limited presence capability
3.	Submarines	• Anti-Surface Warfare • Anti-Submarine Warfare • Land Attack	• Geographic Mobility	• No anti-air capability • No visible presence capability • No anti-land targeting capability • Land attack requires expensive munitions • Communication & coordination difficulties

These considerations suggest that the Navy reallocate its budget to acquire, instead of 15 large-carrier battle groups, some mix of high-ranking high-threat forces and large and small carriers for lower threat uses. One example alternative force is compared to the 15 battle group force in Table 14. It has been assumed in constructing Table 14 that the life cycle costs of six CVN battle groups have been diverted to the high-threat systems shown, but that 15 surface task forces of some type are the mandatory lower bound for low-threat purposes. For these, a mix that maximizes total sea-based aircraft has been taken from Table 10.

Table 14. EQUAL 30-YEAR LIFE CYCLE COST FORCE STRUCTURE (756 Billion FY82 Dollars)

Surface Combatant Force Level Objective Baseline (Battle Group Portion Only)	High Threat Forces: 34 B-1B[a] 34 SSGN[a]
15 Carrier Battle Group	Presence/Crisis Forces
82 Surface Ships:	15 Task Forces
15 CV/CVN	45 Surface Ships[b]:
6 CGN	15 CVVs
31 DDG-51	30 DDG-51
30 DD-963	
1350 Sea-Based Aircraft	900 Sea-Based Aircraft

[a]The numbers of land-based aircraft and SSGNs take into account the costs of 10 days of cruise missile delivery.

[b]From Table 10 (approximately). Other mixes are possible, such as the CVN/LC mix discussed in the previous section which would include seven CVN task forces and eight LC task forces. Theoretically, this mix has fewer total aircraft than the CVV force shown but, when integer numbers of ships are considered, supports essentially the same number of aircraft.

If naval assets were easily replaceable, one might envision substituting for the current Navy (or the Navy's objective of 15 battle groups) a Navy configured as we have outlined above--with a clear separation of high-threat and low-threat forces.

Because of their longer useful lives, however, replacing naval forces is not so easy. The thirty year or greater lifetime of a surface ship suggests that elements of today's Navy will endure well into the early decades of the 21st century. What idealized alternatives (such as shown in Table 14) can do is to point out directions for system procurement that warrant increased attention as existing systems retire, as well as other efforts to develop alternative systems and define requirements. Among the directions suggested by the analysis in the paper are:

1. The acquistion of high-threat systems based on cruise missile technology, as well as acquisition of an inventory of cruise missiles for such missions. Where options exist, such as the B-1B, procurement can begin at once. It is important to emphasize that this procurement is for maritime missions, which is in addition to procurement for other missions (such as strategic roles), since these systems are, in effect, ultimate replacements for battle groups.

Where development work is necessary--for an SSGN or a wide-bodied cruise missile carrier aircraft for maritime operations--appropriate research efforts would seem prudent.

2. An assessment of the low-threat requirements facing the Navy in the future is needed. While any such effort must necessarily be highly speculative, it will focus attention vis-a-vis surface ships on those tasks that surface ships can perform. Needed are estimates of how many task forces are needed as well as projections of potential threats in order to assess what minimum capability is required. Suitable small carrier and escorts designs can then be determined, followed by procurement.

3. Procurement of new CVNs can be delayed. With the two to be procured in 1983, the total number of US CVNs will rise to seven. In addition, the service life extension programs (SLEPs) probably should continue to provide readily available nuclei for low-threat task forces and allow time for the development of smaller carrier designs if these are deemed necessary.

4. Because fewer escorts are needed in lower threat areas, procurement of defensive escorts, particularly Aegis cruisers, should be slowed. The Navy's Five Year SCN plan[1] shows 17 such ships being procured between 1983 and 1987 alone, enough, according to our assumptions, for over eight low-threat task forces. Existing destroyer and cruiser classes should provide some capability into the 1990s, by which time the suitability of the less expensive DDG-51 class and/or Aegis-nuclear cruiser class (for CVNs) can be determined.

5. Investigations into multipurpose sea-based airframes should be pursued. These appear necessary if smaller carriers are to be used in order to satisfy mission requirements and would also be useful on larger carriers.

The setting of overall budgets for the Navy is a dynamic process that depends, among other things, on what systems are procured rather than being a static constraint as we have envisioned it here. Further, increased or decreased emphasis on high-threat missions--a national policy consideration--would alter the relative investments in high-threat and low-threat forces, which in turn could affect system choices. As we have already implied, a closer look at possible low-threat opponents, including future projections, is necessary to truly determine

---

[1]Statement of VAdm. Robert L. Walters, US Navy, Deputy Chief of Naval Operations for Surface Warfare Before the Seapower and Strategic and Critical Materials Subcommittee of the House Armed Services Committee on the FY 1983 Shipbuilding and Conversion Budget Request, 4 March 1982, p. VG-7.

the proper configuration of a low-threat task force. These efforts should pay off in a naval force structure that is less large-carrier oriented but better able to ensure US maritime superiority in peace and war.

Appendix A

LIFE CYCLE COST ANALYSIS

LIFE CYCLE COST ANALYSIS

Rather than attempt a detailed life cycle costing of all the systems examined in this paper, we employ a set of factors which, when multiplied times the procurement costs of various systems, yield approximations of 30-year life cycle costs.

These life cycle cost factors for ships are shown in Table A-1. Ship life cycle costs have been broken into: one procurement for each ship, a midlife conversion for carriers and surface combatants, and 30 years of operations and support (no discounting of costs over time are assumed in any of these factors).

Table A-1. SHIP 30-YEAR LIFE CYCLE COST FACTORS

Ship Type	Procurement +	Midlife Conversion +	30-Year Operating & Support =	LCC Factor
Carriers	1.00	.30	1.70	3.00
Surface Combatants	1.00	.35	1.15	2.50
Submarines	1.00	.00	1.00	2.00
Replenishment Ships	1.00	.00	3.00	4.00

Factors for various aircraft types are listed in Table A-2. These procurement factors take account of the shorter lifetimes of aircraft (relative to ships), peacetime attrition due to accidents and other causes, substitutes purchased for aircraft undergoing depot maintenance, and aircraft bought for training and other support purposes. A life cycle cost factor of 5.00 will also be used for the aircraft-like cruise missiles.

Table A-2. AIRCRAFT 30-YEAR LIFE CYCLE COST FACTORS

Aircraft Type	Procurement	+	30-Year Operating & Support	=	LCC Factor
High Performance Sea-Based Aircraft	5.00		2.00		7.00
Other Sea-Based Aircraft	3.00		2.00		5.00
Long Range Land-Based Aircraft	2.00		3.00		5.00

Battle Group Costs

The total life cycle cost of the battle group component of the Navy is the sum of the life cycle costs of the combatant ships, air wings, and an appropriate amount for underway replenishment.

Surface combatant life cycle cost determinations are outlined in Table A-3, while air wings costs are shown in Table A-4. These air wings employ F/A-18 aircraft to replace the current light attack A-7 and for reconnaissance purposes.

Underway replenishment costs are calculated as shown in Table A-5.

Combining the totals from Tables A-3, A-4 and A-5 yields a 15 battle group life cycle cost of $756 billion.

Costs of Alternative Systems

Table A-6 lists the costs of the alternative force options discussed in Section B of the text. Included in the land-based aircraft costs is the estimated cost of one defended airbase for every 48 operating aircraft. We estimate the procurement cost of such an airbase at $1 billion with a 30-year life cycle cost of $3 billion. Thus, each land-based aircraft is charged an additional $62.5 million to cover basing costs.

Table A-3. BATTLE GROUP COMBATANT SHIPS' LIFE CYCLE COSTS
(Billions of FY 1982 Dollars)

Ship Type	Unit Procurement Cost[1]	No. Ships in 15 Battle Group Navy	Total Procurement Cost	LCC Factor	Total LCC
CVN	2.70	15	55.50	3.00	166.50
CGN	1.34	6	8.04	2.50	20.10
CG-47	1.06	23	24.38	2.50	60.95
DDG-51	0.71	31	22.01	2.50	55.03
DD-963	0.64	30	19.20	2.50	48.00
				Total	350.58

[1]Ship procurement costs for all ships except the DD-963 are from Mitchell, Douglas D., Shipbuilding Costs for General Purpose Forces in a 600 Ship Navy, Congressional Research Service Report 82-23F, February 16, 1982, passim. The DD-963 cost is from "Statement of the Vice Admiral Robert L. Walters, U.S. Navy, Deputy Chief of Naval Operations for Surface Warfare Before the Seapower and Strategic and Critical Materials Subcommittee of the House Armed Services Committee on the FY 1983 Shipbuilding and Conversion Budget Request," 4 March 1982, p.VG-7. The CGN cost is an assumed value.

Table A-4. LIFE CYCLE COSTS OF A TYPICAL CARRIER AIR WING

Aircraft	Unit Procurement Cost (millions of FY82 dollars)[1]	Number	Total Procurement Cost (billions of FY82 dollars)	LCC Factor	Total LCC (billions of FY82 dollars)
F-14	38.7	24	0.93	7	6.50
F/A-18	39.2	24	0.94	7	6.59
A-6	24.6	10	0.25	7	1.72
S-3	22.0	10	0.22	5	1.10
SH-3H	42.9	6	0.26	5	1.29
E-2C	44.2	4	0.18	5	0.88
KA-6D	24.6	4	0.10	5	0.49
EA-6B	45.3	3	0.14	5	0.68
RA-18	39.2	3	0.12	5	0.59
				Total	19.84

[1]All aircraft procurement costs except those for the S-3 and SH-3H are based on Defense Appropriations Hearings Before the Senate Armed Services Committee for Fiscal Year 1982 (Part 3), passim. The SH-3H cost is actually that for the SH-60B which is intended as the SH-3H replacement as the latter begins retiring. The S-3 cost comes from SASC Hearings for Fiscal Year 1976 (Part 3), p.448.

Table A-5. UNDERWAY REPLENISHMENT LIFE CYCLE COSTS PER BATTLE GROUP (Billions) of 1982 Dollars)

Ship	Unit Procurement Cost[1]	Number to Support a Battle Group[2]	Total Procurement Cost	LCC Factor	Fraction of Cost Charged to Battle Group[3]	Total LCC
AOE/ AOR	0.70	1.00	0.70	4.00	0.70	1.96
AO	0.20	1.94	0.39	4.00	0.70	1.09
AE	0.43	1.07	0.46	4.00	0.70	1.29
AFS	0.56	0.60	0.34	4.00	0.70	0.94
DDGX	0.71	0.67	0.48	2.50	0.70	0.83
FFG-7	0.32	2.00	0.64	2.50	0.70	1.12
					Total	7.23

[1]Procurement costs are from Mitchell, loc. cit.

[2]The number of ships to support a carrier battle group is derived from the aforementioned statement of Vice Admiral Walters (see footnote to Table A-3) which provides replenishment ship objectives for a 15-battle group Navy. The number of combatant escorts (DDGX and FFG-7) come from the surface combatant force level objective (SCFLO) presented in that same document.

[3]Surface action groups and deployed amphibious forces will also require underway replenishment; hence some of the underway replenishment costs should be charged to these forces. These only account for 30 percent of the total surface ships constituting battle groups, surface action groups, and amphibious ships. Hence we assume that 70 percent of the underway replenishment costs are attributable to battle group operations.

Table A-6. FORCE OPTION 30-YEAR LIFE CYCLE COSTS (Millions of FY82 Dollars)

Option	Cruise Missile Capacity	Unit Procurement Cost	Life Cycle Cost Factor	Life Cycle Cost	Land-Base Charge	Total
SSN-688(VLS)	25	673	2	1346	-	1346.0
SSGN	125	650	2	1300	-	1300.0
B-1B	22	300	5	1500	62.5	1562.5
CMC	60	100	5	500	62.5	562.5

Appendix B

CRUISE MISSILE DELIVERY CAPABILITY OF CARRIER AIRCRAFT AND ALTERNATIVE SYSTEMS WITH ORDNANCE COSTS AND ATTRITION CONSIDERED

CRUISE MISSILE DELIVERY CAPABILITY OF CARRIER AIRCRAFT AND ALTERNATIVE SYSTEMS WITH ORDNANCE COSTS AND ATTRITION CONSIDERED

The curves shown in Figure 2 compare the total ordnance delivery capability over various days of operations for equal life cycle cost combinations of the various systems considered in this paper. Each point on a curve includes ordnance costs for the corresponding number of days of operations. Thus, except for the carrier aircraft curves (since carrier aircraft provide the baseline to which all the other systems are compared), each curve does not represent the accumulated amount of ordnance delivered by a fixed number of alternative systems, but rather shows the total ordnance delivered over numbers of days by equal life cycle forces as those numbers of days of ordnance are included in the alternative systems' costs. For example, at ten days, the curves show how much ordnance is delivered in ten days by equal life cycle cost forces when ten days' ordnance costs are included in the forces' costs.

The functions generating the curves for the various force options are:

<u>For carrier aircraft</u>:

$$t(1-p)\frac{1-(1-p)^{r\cdot d}}{p}$$

where

d = number of days

t = total cruise missile equivalents delivered by unattritted carrier air wings per sortie (333 1/3)

p = carrier aircraft attrition rate (.01, .05, .10, or .20)

r = carrier aircraft sortie rate (1.5 sorties per aircraft per day).

<u>For land-based aircraft</u>:

$$(1-a)\cdot d\cdot s\cdot w\cdot(C_{BG}+C_{OBG}\cdot d)/(C_A+C_{CM}\cdot s\cdot w\cdot d) \quad \text{(no attrition)}$$

$$(1-a)\cdot w\cdot(1-p)\left(\frac{1-(1-p)^{s\cdot d}}{p}\right)\cdot(C_{BG}+C_{OBG}\cdot d)/(C_A+C_{CM}\cdot s\cdot w\cdot d)$$

(positive attrition)

where

a = cruise missile attrition rate (0.20)

d = number of days

s = land-based aircraft sortie rate (0.50)

w = aircraft cruise missile load (22 for B-1B, 60 for CMC)

p = land-based aircraft attrition rate (.01, .05, .10, or .20)

C_{BG} = battle group life cycle cost ($100.8 billion)

C_{OBG} = life cycle cost of one day's carrier aircraft ordnance ($1.5 million)

C_A = land-based aircraft life cycle cost, including basing costs ($1562 million for B-1B, $562 million for CMC)

C_{CM} = cruise missile life cycle cost ($13 million).

For cruise missile submarines:

$$(1-a)\cdot w\cdot\left(\frac{1-(1-g)^f}{g}\right)(C_{BG}+C_{OBG}\cdot d)/(C_S+C_{CM}\cdot f\cdot w)$$

where

a = cruise missile attrition rate (0.20)

g = submarine attrition rate after launch (0.10)

d = number of days

f = number of missions the submarine can accomplish in d days (1 if $d \leq 15$, 2 if $16 \leq d \leq 30$)

w = submarine cruise missile load (25 for SSN-688(VLS), 125 for SSGN)

C_{BG} = battle group life cycle cost ($100.8 billion)

C_{OBG} = life cycle cost of one day's carrier aircraft ordnance ($1.5 million)

C_S = submarine life cycle cost ($1346 for SSN-688(VLS), $1300 for SSGN)

C_{CM} = cruise missile life cycle cost ($13 million).

Appendix C

RESULTS OF CAMPAIGN MODEL

RESULTS OF CAMPAIGN MODEL

This Appendix tabulates the outcome of ten days' campaign between an attacking force and from one to four LTTFs. The assumptions of this campaign are described in the text. For each case, 500 runs of a Monte Carlo simulation were conducted and runs averaged. The Monte-Carloed event was the destruction of an LTTF. Table C-1 lists the expected number of LTTFs surviving after ten days of varying values of p, the probability that an undegraded attacking force puts an LTTF out of action, and a, the degradation suffered by the attacking force after mounting an attack.

Table C-1

p \ a	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
0	1.00 2.00 3.00 4.00	1.00 2.00 3.00 4.00	1.00 2.00 3.00 4.00	1.00 2.00 3.00 4.00	1.00 2.00 3.00 4.00	1.00 2.00 3.00 4.00	1.00 2.00 3.00 4.00	1.00 2.00 3.00 4.00	1.00 2.00 3.00 4.00	1.00 2.00 3.00 4.00	1.00 2.00 3.00 4.00
.1	.34 .75 1.16 1.45	.47 1.22 2.12 3.05	.66 1.54 2.56 3.53	.70 1.66 2.70 3.70	.77 1.76 2.74 3.78	.82 1.80 2.79 3.81	.85 1.83 2.85 3.83	.85 1.87 2.86 3.88	.85 1.87 2.90 3.88	.88 1.88 2.90 3.88	.90 1.90 2.91 3.90
.2	.06 .24 .38 .56	.23 .75 1.42 2.20	.37 1.08 2.02 3.03	.50 1.35 2.34 3.37	.58 1.55 2.52 3.49	.64 1.56 2.67 3.61	.67 1.65 2.69 3.64	.74 1.70 2.70 3.70	.76 1.76 2.73 3.74	.81 1.75 2.78 3.76	.77 1.79 2.81 3.81
.3	.05 .06 .10 .15	.10 .37 .82 1.48	.23 .76 1.61 2.50	.32 1.06 2.01 3.04	.45 1.22 2.26 3.25	.50 1.45 2.45 3.41	.58 1.45 2.52 3.53	.64 1.59 2.55 3.56	.61 1.61 2.68 3.59	.66 1.68 2.67 3.67	.75 1.68 2.71 3.72
.4	.01 .01 .03 .03	.04 .18 .47 .87	.11 .50 1.18 2.06	.23 .83 1.69 2.71	.32 1.07 2.05 3.03	.41 1.27 2.21 3.18	.44 1.40 2.34 3.36	.46 1.46 2.42 3.45	.53 1.53 2.51 3.53	.56 1.56 2.56 3.59	.58 1.58 2.57 3.63
.5	0 0 .01 0	.01 .07 .30 .51	.07 .36 .87 1.73	.14 .61 1.36 2.34	.23 .81 1.76 2.68	.27 1.05 1.95 3.04	.36 1.18 2.19 3.21	.39 1.25 2.25 3.34	.43 1.34 2.35 3.41	.47 1.52 2.48 3.43	.50 1.48 2.46 3.51
.6	0 0 0 0	0 .02 .11 .31	.03 .22 .59 1.23	.07 .40 1.19 2.01	.17 .71 1.50 2.58	.21 .86 1.75 2.72	.25 1.02 2.00 3.01	.28 1.18 2.13 3.17	.37 1.25 2.28 3.25	.36 1.34 2.34 3.29	.41 1.38 2.41 3.39
.7	0 0 0 0	.01 .01 .04 .16	.02 .11 .41 .94	.04 .27 .87 1.62	.08 .50 1.34 2.27	.14 .75 1.65 2.63	.20 .87 1.88 2.83	.23 1.01 2.00 3.04	.24 1.17 2.13 3.60	.29 1.24 2.20 3.19	.30 1.31 2.29 3.31
.8	0 0 0 0	0 .01 .01 .05	0 .05 .27 .61	.02 .19 .59 1.45	.04 .40 1.09 1.97	.05 .53 1.40 2.46	.10 .71 1.72 2.67	.14 .89 1.78 2.80	.15 1.04 1.97 3.01	.18 1.13 2.12 3.14	.18 1.20 2.18 3.20
.9	0 0 0 0	0 0 0 .03	0 .02 .11 .37	.01 .12 .42 1.10	.01 .23 .87 1.77	.01 .44 1.25 2.17	.05 .56 1.51 2.52	.06 .77 1.71 2.68	.07 .86 1.42 2.84	07 .99 1.98 2.92	.08 1.07 2.10 3.07
1.0	0 0 0 0	0 0 0 0	0 0 .06 .26	0 .04 .29 .94	0 .17 .68 1.52	0 .27 1.10 1.98	0 .44 1.39 2.32	0 .59 1.56 2.62	0 .74 1.77 2.77	0 .88 1.89 2.87	0 1.00 2.00 3.00

NOTE: Each entry consists of four numbers listed vertically. The first is the expected number of LTTFs surviving after ten days out of one in the operating area; the second is the expected number of LTTFs surviving out of two in the operating area, and so forth up to four.

U210420